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Improving Operational Safety on Local Roads and Streets

Presented by
the Georgia Local Technical Assistance Program (LTAP)
February, 2000

Locations:

February 1 - Alpharetta February 3 - Macon
February 8 - Savannah February 10 - Valdosta
February 15 - Athens February 22 - Rome
February 24 - Sandersville

FINAL REPORT

May, 2000

Jointly Sponsored by:
Georgia Department of Transportation's
Technology Transfer Center
Georgia Transportation Institute
Federal Highway Administration

Instructor
Peter S. Parsonson, Ph.D., P.E.
School of Civil and Environmental Engineering
Georgia Tech

Under an agreement between the Georgia DOT and the Georgia Tech Research Corporation

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May 10, 2000

Mr. Rick Smith, Assistant Director
Local Technical Assistance Program (LTAP)
Technology Transfer Center
Georgia DOT
276 Memorial Drive
Atlanta, GA 30303

Dear Mr. Smith:

**Consultant Services Contract -
"Improving Operational Safety on Local Roads and Streets"**
GIT Project E-20-E14, AGR DTD 980915, Mod LTR DTD 990428

We are pleased to submit this Final Report on the subject contract. It began on September 15, 1998, and by Supplemental Agreement the termination date was extended to June 1, 2000 with no change in budget.

The purpose of the project was to update the existing FHWA document *Improving Operational Safety on Local Roads and Streets*, in consultation with the Department, and to present a one-day course to local personnel in each of the Department's seven districts. The presentations were made in February of 2000 and included a PowerPoint presentation accompanied by various videos and an exercise with microscopes and reflective sheeting. Each participant received a Participant's Guide. This Final Report comprises the following deliverables:

- Participants' Guide, in reproducible form and on a Zip disk, as revised after the presentations. The Guide includes a PowerPoint file and an MS Word file for each section of the course.
- Instructor's Guide, in reproducible form and on a Zip disk
- Copies of the videos shown
- Four microscopes purchased for the course, with samples of reflective sheeting
- Tabulations of the Participants' Evaluations of the course
- Originals of the Participants' Evaluations, submitted as a separate deliverable

The presentations were made at the following cities on the dates shown:

February 1 - Alpharetta	Feb 3 - Macon	Feb 8 - Savannah	
Feb 10 - Valdosta	Feb 15 - Athens	Feb 22 - Rome	Feb 24 - Sandersville

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The enclosed tabulations of the Participants' Evaluations indicate that the course was a great success, meeting or exceeding the expectations of almost all the participants. The Evaluation form asked the participants to indicate those parts of the course that they would like to see expanded into a follow-up course. Three of the seven groups gave top priority to Section 5, titled Signals, but three others gave most votes to Section 7, When Sight Distance is Obstructed. Section 6, Some Operational Safety Improvements, was also mentioned prominently, probably because it included some coverage of traffic calming.

By Spring of 2001 it is expected that the millennium edition of the *Manual on Uniform Traffic Control Devices* will be published by the Federal Highway Administration. There will be a strong demand for a one-day course to cover the many new provisions of this document. Also, in December of 1998 the Federal Highway Administration published an *Older Driver Highway Design Handbook: Recommendations and Guidelines* that is sure to be of enormous interest when the local engineers realize that the document is recommending practices far more conservative than those practiced at present. The Georgia Division office of the FHWA has already prepared a PowerPoint presentation on this document and is planning to offer one-day courses in Augusta and Savannah, probably, during 2000.

In summary, this course was well received, and there is substantial demand for certain follow-on courses on the subject of traffic operations.

Georgia Tech was very pleased to be selected to perform this contract. We stand ready to assist the Department in the future in its LTAP program.

Sincerely,

A handwritten signature in black ink, appearing to read "Peter Parsonson", with a long, sweeping horizontal line extending to the right.

Peter S. Parsonson, PhD, PE
Professor and Project Director

Encl (separate): Originals of Participants' Evaluations
Videos, microscopes, reflective-sheeting samples
Zip disk of PowerPoint and Word files

--PRINTING INSTRUCTIONS--

IT IS INTENDED THAT ALL PRINTING WILL BE DOUBLE SIDED. EACH PRINTED NOTEBOOK SECTION WILL HAVE ITS TITLE PAGE ON THE RIGHT. AS THE READER TURNS PAST THE TITLE PAGE, THE FIGURES (SUCH AS PAGE 1-1) WILL BE ON THE LEFT AND THE CORRESPONDINGLY NUMBERED TEXT PARAGRAPHS (SUCH AS PAGE 1-2) WILL BE PRINTED ON THE RIGHT. THIS WAY, THE READER CAN SEE THE TEXT CORRESPONDING TO THE FIGURES WITHOUT TURNING PAGES BACK AND FORTH.



LTAP

The Georgia Local Technical Assistance Program
presents

Improving Operational Safety on Local Roads and Streets

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FOREWORD

This document is the Participant Guide for a one-day (five hour) course “Improving Operational Safety on Local Roads and Streets.” There is a companion Instructor’s Guide, a set of PowerPoint slides, several videos, samples of reflective sheeting, lighted microscopes for examining the sheeting, and several other demonstration items comprising the course materials. These were prepared as an update and expansion of a 46-page document with the same title published in 1988 by the Federal Highway Administration as report FHWA-RT-88-039. The intentions then and now have been to provide a general guide to effective, low-cost methods to improve and enhance operational safety, a term referring to the formal sources of information needed by the driver to control and maintain the vehicle on the roadway system and in the traffic environment. These formal sources are the traffic-control devices used, including signs, markings and signals.

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IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 1

INTRODUCTION TO OPERATIONAL SAFETY

1.0 INTRODUCTION

This section of *Improving Operational Safety on Local Roads and Streets* contrasts operational improvements with types not covered herein. It goes on to explain the need to provide **positive guidance** to the driver by means of appropriate traffic-control devices. All devices need to meet requirements of uniformity, design, placement, operation and maintenance. This notebook, and the course on which it is based, draw on some of the documents and videos listed in the *Local Technical Assistance Program, 1997, Resources Directory* (1).

1.1 HIGHWAY SAFETY IMPROVEMENTS

This notebook deals only with **operational** improvements, which provide the driver with information, usually through signs, markings, signals, and other means such as rumble strips and speed humps. Not within the scope of this notebook are **roadway** improvements that are geometric in nature, nor are **roadside** improvements, such as guardrail. Neither does the scope include safety during **work-zone** operations, which include construction, maintenance, utility, and incident-management operations. Work-zone operational safety is addressed by Part VI of the *Manual on Uniform Traffic Control Devices* (2), many other documents published by the Federal Highway Administration (FHWA), such as (3), and by various publications, videos and courses produced by the American Traffic Safety Services Association (ATSSA), such as (4).

1.2 NEED FOR POSITIVE GUIDANCE

The concept of **positive guidance** was developed by engineering psychologists with the FHWA in the early 1970s. The approach links traffic engineering with human-factors considerations to provide the driver with sufficient information *where* it is needed, and in the *form* needed, to avoid crashes at hazardous locations. For example, a rural site in Virginia is shown in Figure 1.2.A (5). East of the parking lot the roadway's geometry and design change from fair to poor, with inadequate shoulders, narrower lanes, poor sight distance, and multiple horizontal and vertical curves. The existing signs and markings, prior to the positive-guidance analysis, are shown in Figure 1.2.B. A Left Arrow facing eastbound traffic in the reverse curve just east of the parking lot is barely visible over the crest of the hill in Figure 1.2.C. The positive-guidance analysis produced eight changes

shown in Figure 1.2.D (6). The revised plan strives to satisfy all information needs, avoid surprises, avoid expectancy violations (discussed next), and spread the information over sufficient travel time and distance so that drivers will not be overloaded and confused. Positive guidance provides high-payoff, short-range solutions to safety and operational problems at relatively low cost.

1.3 DRIVER EXPECTANCY IS THE KEY

A vital concept of positive guidance is driver expectancy. Through previous conditioning over time, a driver adopts certain understandings and assumptions regarding roadway conditions, traffic situations, or information systems. At locations where driver expectancies are violated, drivers may respond too late or incorrectly. An example is a tangential intersection on a curve, Figure 1.3.A. A less-than-alert driver could be unintentionally “pulled off” the main road by following the heretofore straight road onto the minor road. In Figure 1.3.B, a driver may run off the road, especially at night, because of an expectancy that the road follows the line of utility poles (7). Positive guidance requires the addition of warning signs, delineators, or markings to emphasize the true alignment here. Driver expectancy is a key concept, as it focuses attention on the driver’s point of view.

1.4 AGEING DRIVERS AT NIGHT

Studies have shown that a 40-year-old driver requires four times as much light to see as a 20-year-old, and a 60-year-old driver requires eight times as much (8). Considerable attention is currently focused on the needs of an ageing driver population (9, 10). The Institute of Transportation Engineers (ITE) pointed out in 1993 that “The need for conspicuous and legible traffic signs is especially important at night. Accident statistics indicate more than 50 percent of the traffic fatalities occur in darkness, and the fatality rate for miles of travel is more than three times higher than during daylight hours. While fatigue and intoxication may enter into the higher accident numbers and rates, they do not account for the total difference” (11).

1.5 TRAFFIC CONTROL DEVICES

Traffic engineers communicate with drivers through traffic control devices, primarily signs, markings and signals. The messages communicated must be simple and clear, and presented in a way that encourages proper and timely response.

1.5.1 THE *MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES*

The *Manual on Uniform Traffic Control Devices (MUTCD)* (2) is the principal standard regulating the use, placement and design of traffic control devices for all streets and highways open to public travel, regardless of type or class or the governmental agency having jurisdiction. Local agencies must adopt the *MUTCD* of their state. A national model *MUTCD* is published by the FHWA and is adopted by most states. A few states develop their own manual, which may impose additional or more-stringent standards, but must meet all of the minimum standards of the federal model and be approved by the USDOT. For this reason, all versions of the *MUTCD* are quite alike and serve to establish uniformity in the appearance and application of traffic control devices. Uniformity simplifies the task of drivers, pedestrians and bicyclists because it aids in recognition and understanding. By treating similar situations in the same way, agencies gain the respect of the traveling public, interpret traffic laws more consistently, and save money by manufacturing and storing fewer types of signs.

1.5.2 THE *TRAFFIC CONTROL DEVICES HANDBOOK*

The *Traffic Control Devices Handbook (TCDH)* (3) is published by the USDOT as a companion to the *MUTCD*, to augment it “by serving an interpretative function and by linking the *MUTCD* standards and warrants with the activities related to complying with these national uniform standards . . . The Handbook offers guidelines for implementing the standards and applications contained in the Manual.” For example, the *MUTCD* states that an Advisory Speed plate may be used under a warning sign “to indicate the maximum recommended speed around a curve or through a hazardous location.” The *TCDH*, in turn, explains various procedures to determine the maximum recommended speed around a curve. The *TCDH* provides detailed information on the selection, installation and maintenance of all types of traffic-control devices, and deserves a place on the bookshelf next to the *MUTCD*.

1.5.3 FIVE BASIC REQUIREMENTS AND FIVE FACTORS IN MEETING THEM

The *MUTCD* explains that, to be effective, any and every traffic-control device should meet five basic requirements:

1. Fulfill a need
2. Command attention
3. Convey a clear, simple meaning
4. Command respect of road users
5. Give adequate time [and distance] for proper response

These are met by taking five basic factors into account:

1. Design
 2. Placement
 3. Operation or application
 4. Maintenance
 5. Uniformity
-

1.5.4 DESIGN

The design of the device should draw attention to it, produce a clear meaning, command respect and give adequate time and distance for response. The figure shows a 20-mph speed-limit sign posted at the entrance to a large race track in northeastern United States. The sign was incorrectly placed on a STOP-sign blank and is not the rectangular, black-letter-on-white-background layout required of a regulatory sign. While it may draw attention as a curiosity, it does not clearly indicate an enforceable speed limit.

1.5.5 ANOTHER DESIGN EXAMPLE

Figure 1.5.5.A shows a location in the southeast where the roadways of a one-way pair are separated by a 223-foot-wide median. The one-way roadways have the right of way, and traffic on the crossroad must make two stops as it crosses the one-way pair. Frequent right-angle crashes and complaints of confusing operation caused the city to add the non-standard signs “Traffic From Left Not Required to Stop” and “Traffic From Right Not Required to Stop” at the two intersections, respectively. The crashes and complaints persisted, despite rumble strips and painted STOP legends on the pavement. Curiously, the city did not install the DIVIDED HIGHWAY sign intended for the approach legs of a roadway that intersects a divided highway. The design failed to convey a clear and simple meaning. None of the many devices in place conveyed the simple concept of “divided highway.”

1.5.6 PLACEMENT

Placement should command attention and give time and distance for response. The speed-limit sign lettered on the STOP sign in the figure is poorly located, too close to the intersection. The driver of the turning car will find it difficult to see this sign.

1.5.7 ANOTHER PLACEMENT EXAMPLE

The figure shows a location in the northwest where a 55-mph rural road turns sharply to the left before coming to a STOP sign at the intersection with a highway. The curve has a recommended safe speed of only 15 mph. The STOP AHEAD sign is only 222 feet from the curve, less than half the distance needed to decelerate from 55 to 15 mph, and is also outdated in its design, with words rather than symbols. Neither does it take the place of the needed Turn to Left warning sign, with a 15-mph Advisory Speed plate. The sharp turn was not readily visible at night and therefore constituted a latent hazard, a trap for the unwary driver.

1.5.8 OPERATION OR APPLICATION

Operation or application requires that appropriate devices and associated equipment be installed at the location. While “equipment” implies traffic-signal-control equipment, absence of needed signs or markings are also examples. The figure shows an Interstate loop ramp that gives no hint of the need to decelerate to 20 mph on the tight curve that lies ahead, out of sight (especially at night).

1.5.9 MAINTENANCE

Examples of poorly maintained devices are all too easy to find. The figure shows the post of an Object Marker plate that had been warning of the end of a lane. It had been down for a long time. The *AASHTO Maintenance Manual--1987* (12) includes a helpful chapter on maintenance-management systems and a chapter specifically on the maintenance of traffic-control devices.

1.5.10 FUNCTIONAL MAINTENANCE

Section 1A-2 of the *MUTCD* states “. . . functional maintenance is required to adjust needed traffic control devices to current conditions . . .” Traffic engineers should not underestimate what improvements in devices might be required under this principle. For example, current conditions on an intersection approach might indicate the need for dou-

ble-indicating the STOP AHEAD sign and even adding rumble strips. The concept of functional maintenance goes well beyond the conservation of existing devices.

1.5.11 THE *MUTCD* IS NOT A COOKBOOK

The *MUTCD* in Section 1A-4 recommends that “The decision to use a particular device at a particular location should be made on the basis of an engineering study of the location. Thus, while this Manual provides standards for design and application of traffic control devices, the Manual is not a substitute for engineering judgment.” The *MUTCD* is not a cookbook to be applied by an unqualified engineer or by a non-engineer who may have had some training in its provisions. Especially where the geometric design is bad, as in Figure 1.5.7, above, the traffic engineer should go beyond the minimums of the *MUTCD*, in an attempt to make the location reasonably safe. “Jurisdictions with responsibility for traffic control that do not have qualified engineers on their staffs should seek assistance from the State highway department, their county, a nearby large city, or a traffic consultant.”

1.5.12 MEANINGS OF “SHALL,” “SHOULD” AND “MAY”

Section 1A-5 of the *MUTCD* explains that “SHALL” is a mandatory condition, as, for example, “The STOP sign shall be an octagon with white message and border on a red background.” SHOULD means advisable usage, recommended but not mandatory, as in “A STOP sign should be erected at the point where the vehicle is to stop or as near thereto as possible . . .” SHOULD leaves some discretion to depart from the advisable usage for good reason, which desirably is to be documented as a matter of good record-keeping practice. The legal meaning of SHOULD varies from state to state, and needs to be interpreted by an attorney who keeps up with the case law in this area. MAY is entirely a permissive condition, as in the provision that “A STOP sign beacon may be used in conjunction with a STOP sign.” Again, case law will determine the precise meaning.

1.6 REFERENCES FOR SECTION 1

1. U.S. Department of Transportation, *Local Technical Assistance Program, 1997, Resources Directory*, FHWA-SA-97-099, Federal Highway Administration, Washington, D.C., 1997. Lists course materials, manuals, videos available in 14 areas such as safety, signs and signals, risk management, etc. Available from the FHWA research and Technology Report Center, Lanham, Maryland, (301)577-0818.
2. U.S. Department of Transportation, *Manual on Uniform Traffic Control Devices*, Washington, D.C., Federal Highway Administration, 1988. This manual has been adopted by Georgia for the State Highway System, city streets and county roads.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 2

SIGNS

2.0 INTRODUCTION

This section discusses traffic signs, which are the basic means of providing information to drivers, bicyclists and pedestrians. Keep in mind, however, that road users “read” the road itself and primarily take their cues from it and from the overall operating environment. Traffic engineers have known for many years that signing cannot eliminate problems resulting from poor geometric design. Coverage of chevron alignment signs is postponed to Section 4, titled Delineators.

2.1 REGULATORY, WARNING AND GUIDE SIGNS

Signs are classified according to their function, as follows:

- Regulatory signs inform road users that special laws or ordinances apply at specific places and times. Many regulatory signs are rectangular and have black letters on a white background, but there are several exceptions, such as the STOP sign.
 - Warning signs advise road users of potentially hazardous locations, maneuvers or activities. They are diamond-shaped, typically with black letters or symbols on a yellow background.
 - Guide signs give information concerning routes, directions, destinations, points of interest and services. A common type of guide sign is rectangular with a white message on a green background.
-

2.2 BASIC PRINCIPLES OF SIGNING

The following suggestions are offered for the application of signs:

- Use frequent route markers and directional signs. However, regulatory and warning signs will lose their effectiveness if used to excess, so be sure there is a real need.
- Confront the driver with a single, simple decision at a time. Don’t overload drivers with more information than they can process.
- Place the sign far enough ahead to allow sufficient time and distance to respond.
- Maintain your signs well so that they command the attention and respect of the road user.

The sign in the figure is not clear, as the .3 could be mistaken for 3. Use simple fractions, such as $\frac{1}{4}$, following examples in the *MUTCD* (1).

2.3 MOST SIGN LOCATIONS NEED WORK

A 1988 field survey of traffic signs in one urban/suburban area found that 60 percent of locations surveyed needed some form of action, as shown below (2):

Signs to be left unchanged	40%
Signs requiring a new face of the same type	16%
Signs missing or requiring new installation	31%
Signs to be permanently removed	12%
Signs to be relocated	1%

The sign in the figure needs to be relocated farther from the corner, so that right-turning drivers can read it more easily.

2.4 SIGNING IMPROVEMENTS ARE COST-EFFECTIVE

A 1992 Federal report (3) found that signing improvements ranked as the third most cost-effective highway-safety improvement, with a benefit-cost ratio of 7.3.

2.5 SIGN RETROREFLECTIVITY IS VITAL FOR OUR SENIOR DRIVERS

The *MUTCD* calls for all warning, regulatory and overhead guide signs to be reflectorized or illuminated to show the same shape and color day and night. Most signs are fabricated with a retroreflective sheeting containing glass beads or micro-prisms that reflect incident light from headlights back to the source. The sheeting comes in various qualities, the least expensive of which uses 1950's technology and will lose much of its reflectivity in about seven years and require replacement (4). Sign brightness at night is an important issue, especially for our senior drivers.

The figures show that a sign that is legible in daylight may not be legible at night (5).

2.6 SELECTION OF SIGN RETROREFLECTIVE MATERIAL

One manufacturer classifies its reflective sheeting as follows (6):

- Engineer Grade
- High Intensity Grade
- Diamond Grade

A sign manufacturer may guarantee that the retroreflectivity of an Engineering Grade sign will not deteriorate more than 50 percent over a seven-year period, while a more expensive High-Performance Grade product may be guaranteed to retain at least 80 percent of its original brightness after 10 years on the roadway. A study done for the Kansas DOT in 1988 found that the more-expensive and longer-lasting high-performance sheeting is more cost-effective (4). The figures showing the better grade are from Reference 6.

2.7 EXERCISE WITH MICROSCOPES AND REFLECTIVE SHEETING

The differences in the grades of sheeting are evident when they are compared under a lighted 100X microscope, readily available from electronics stores. The encapsulated glass-bead (High Intensity) design is easy to differentiate from the enclosed-bead (Engineer Grade) design. The micro-prism designs have precisely molded corner-cube reflex elements that make them totally different from the glass-bead types. The diamond-shaped prisms are seen to be very bright.

2.8 MUTCD CALLS FOR SIGN INSPECTION AND MAINTENANCE

“All traffic signs should be kept in proper position, clean and legible at all times. Damaged signs should be replaced without undue delay.” Agency personnel who travel around the jurisdiction in the course of their duties should be instructed to report by radio any obscured or damaged sign. All signs should be checked at night for legibility and reflectivity, because of the high incidence of nighttime crashes.

2.9 MISSISSIPPI VIDEO “ALTERNATIVE TO NIGHTTIME SIGN INSPECTION”

There is a procedure using a readily available, high-powered, hand-held light to check sign reflectivity during the daytime. It works especially well on rainy days and is convenient when construction is shut down due to rain and personnel are available to check signs. It may reduce night inspection, but is not intended to eliminate it. The video is by the Mississippi Highway Department.

2.10 SIGN-REPLACEMENT PROGRAMS

There are still no minimum performance guidelines to specify when retroreflective traffic signs should be replaced. It is best to establish a systematic program to replace a certain percentage of signs each year. For example, if 10-year-life sheeting is used, the city could be divided into 10 zones. Each year the sign department would replace all the signs in one zone. Another system recognizes that the red-series signs (STOP, YIELD, DO NOT ENTER, WRONG WAY) require an immediate maintenance response.

2.11 ATSSA VIDEO “NEW DIRECTIONS IN SIGN MANAGEMENT”

This video, from the American Traffic Safety Services Association (7), offers practical advice on sign-replacement programs. Copies of a six-page booklet accompany the video and give the viewer a lasting record of its main points.

2.12 COMBATING SIGN VANDALISM

Theft of and damage to signs by vandals has long been a big problem. Theft can be reduced by using vandal-resistant fasteners or by hammering the bolt end so that the sign cannot be removed using ordinary hand tools. Higher mounting is effective. The State of Iowa made illegal possession of a traffic sign a serious misdemeanor (2). A plywood or lexan sign blank is not damaged as much by bullets, and fails to produce such a satisfying “twang” for the vandal.

2.13 DETAILS OF SIGN-MAKING

The *Traffic Control Devices Handbook* (8) provides detailed guidance on sign-making equipment, materials and procedures. Exact dimensions are given in Reference 8. In 1992 the FHWA published a report on innovative practices in sign fabrication, installation and maintenance (10).

2.14 SIGNS CAN BE A ROADSIDE HAZARD

All sign supports that can be reached and struck by a vehicle should be crashworthy. The base of a breakaway design must not protrude more than 4 inches above the ground. Alternatively, the sign can be relocated to where it cannot be hit, such as on an overhead structure, behind guardrail, or well up a cut slope, provided it is still acceptably visible there (5). Detailed information on sign supports is found in AASHTO's *Roadside Design Guide* (11).

2.15 NEW METHOD TO MAKE STREET-NAME SIGNS

Monroe County, New York has developed a new reverse-screening method of manufacturing street-name signs (2). "This technique has increased productivity from 50 to 250 signs per day and has reduced costs from \$3.20 to 22 cents per side . . . and has added five years to the life of the sign. The county has also developed a vandal-proof bracket for mounting the street-name signs, saving an estimated \$36,000."

2.16 SENIOR DRIVERS NEED BETTER TRAFFIC SIGNS

The Illinois DOT tested a group of older drivers in 1990 (2). It was found that street-name signs need to be larger, advance guide signs need to give drivers more time to get into the correct lane for turning or exiting, and route markers need to be larger and more numerous.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 3

PAVEMENT MARKINGS

3.0 INTRODUCTION

This section describes markings applied to the road surface using paint, thermoplastic materials and epoxies, or raised pavement-markers. Coverage of object markers and post-mounted delineators is postponed to Section 4, Delineators. Pavement markings can be covered by snow and may be hard to see on a rainy or foggy night; however, most of the time they are very effective in providing positive guidance, especially at night, because they are directly in the driver's line of sight and are bright due to their retroreflectivity.

3.1 CATEGORIES OF MARKINGS

Pavement markings are classified in Part III of the *MUTCD* (1), as summarized next:

- Longitudinal markings, including centerlines, lane lines and edge lines
 - Transverse markings, comprising shoulder markings, word and symbol markings, stop lines, crosswalk lines and parking-space markings
 - Curb markings, which include delineators and parking regulations
 - Raised pavement markers (RPMs)
-

3.2 MARKINGS ARE EXTREMELY COST-EFFECTIVE

About \$400 million dollars per year are spent on pavement markings. They are an extraordinarily effective highway improvement. Studies have shown that existing longitudinal pavement markings reduce crashes by 21 percent, and edge lines on rural two-lane highways reduce crashes by 8 percent. Those percentages led to the conclusion that markings yield benefits of \$60 in crash-cost reduction for every dollar spent on markings (2, 3). Because pavement markings save lives and reduce congestion, it is unfortunate that markings on many city streets and county roads are not well maintained. The figures show how low-cost improvements can remove the confusing "sea of pavement" at a Y intersection, and give drivers the positive guidance they need for safety.

3.3 ATSSA VIDEO "RIGHT BEFORE YOUR EYES"

This is a non-technical video that might be useful in convincing local elected officials of the value of an adequately funded program for pavement marking. Copies of an accompanying pamphlet can be given to them at the time of viewing.

3.4 LONGITUDINAL LINES

Centerlines, lane lines and edge lines have various widths and patterns as follows (1):

- Normal width: 4 to 6 inches
- Wide line: at least twice the width of a normal 4-inch line
- Broken line: on rural highways, usually formed by 10-foot segments and 30-foot gaps
- Dotted line: normally formed by 2-foot segments and gaps 4 feet or longer

Research has shown that every dollar spent on 4-inch-wide edge lines for even a very-low-volume (500 vpd) two-lane rural road yields \$17 in safety benefits (4).

The figures show how effective it was to restripe a double centerline on this winding country road.

3.5 TRANSVERSE LINES

Because of their limitations in the presence of snow, ice and rain, transverse markings, especially, need a contrasting color during the day and retroreflectivity at night.

Driver distraction is an increasing problem, so it is more important than ever for stop lines to have their full 12-to-24-inch width and to extend across all approach lanes. Word and symbol messages on the pavement can be effective countermeasures to certain types of crashes. The STOP legend in the figure must be accompanied by a STOP sign

Pedestrian crosswalks consist conventionally of a pair of transverse lines; however, the type shown in the figure, formed of a number of longitudinal segments, is much more visible to the approaching driver.

3.6 RETROREFLECTIVE MARKINGS

Spherical glass beads are immediately dropped into the fresh paint or thermoplastic material. The figure shows how the entering rays from the vehicle's headlights are refracted and reflected back toward their source, very close to where the driver's eyes are located. When a headlight beam strikes thousands of these beads, the line appears very bright to the driver (5).

3.7 RAINWATER INTERFERES WITH RETROREFLECTIVITY

The brightness of markings diminishes when the road is wet and the beads are covered with water. Larger beads are one solution. The figures show another, a tape manufactured with a three-dimensional, waffled surface that raises the beads above the water (6,7). A third solution is the use of raised pavement markers (RPMs), discussed below.

3.8 PAVEMENT MARKING EQUIPMENT AND PROCEDURES

The *Traffic Control Devices Handbook* (5) provides detailed guidance on equipment and procedures to install painted markings, hot- and cold-laid thermoplastic markings, and raised pavement markers, including the snowplowable models. The American Traffic Safety Services Association (ATSSA) offers several videos on the inspection of pavement markings applied by paint, thermoplastics and epoxies, and presents training and certification courses for pavement marking technicians at various locations nationwide throughout the year (8).

3.9 ATSSA VIDEO "PAVEMENT MARKING INSPECTION: TRAFFIC PAINT"

This video, from the American Traffic Safety Services Association, covers the basics of traffic-paint application, including materials/equipment, pavement preparation, road/air temperatures, layout and premarking, paint preparation, marking quality and workmanship, measuring and calculating paint thickness, glass-bead application, checking retroreflectivity, and documentation. Copies of a vest-pocket-sized Inspector's Guide summarize the important points.

3.10 MANAGEMENT OF PAVEMENT-MARKING PROGRAMS

The life and performance of each pavement-marking material are in line with its cost. Local agencies should have a policy for the selection of their pavement-marking materials. The policy should identify each type of material and specify which one is to be used on each type of road or street, as classified according to traffic volume and the type of surface. Reference 9 discusses management practices and material-selection procedures. It includes graphs estimating the useful lives of various materials as a function of traffic volume and annual inches of snowfall. For example, solvent-borne paint applied to asphalt pavement in an area with little snowfall will last from 5 to 16 months, depending on traffic volume. By contrast, a thermoplastic marking there will last eight to nine years.

3.11 CAUSES OF PAVEMENT-MARKING FAILURES

Common causes of premature pavement-marking failures are as follows (10):

- Insufficient cleaning of the pavement
- Overthinning of the paint
- Damp or wet pavement
- Applying on windy days
- Applying when temperature is below 40 degrees F.
- Presence of alkaline material on the roadway
- Insufficient paint-film-thickness applied
- Insufficient glass beads applied

This list makes it clear that the marking inspector must do his or her job well.

3.12 RAISED PAVEMENT MARKERS (RPMs)

RPMs are durable, retroreflective devices that are fastened to the pavement surface. Because they rise about one-half inch above the level of rainwater, they continue to provide retroreflectivity on dark, wet nights. The figures show how their cube corner (prismatic) reflectors gather and return light in a narrow beam, making them very bright (11). The impact of driving over an RPM can be felt through the steering wheel and heard, adding to the visual warning it provides. A transverse row of non-reflectorized RPMs also provides tactile and audible warnings, similar to those of a rumble strip. Red RPMs can be used to convey a "Wrong Way" message. Various models of snowplowable RPMs are available.

3.13 REFERENCES FOR SECTION 3

1. U.S. Department of Transportation, *Manual on Uniform Traffic Control Devices*, Washington, D.C., Federal Highway Administration, 1988.
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 3. Institute of Transportation Engineers, *The Traffic Safety Toolbox: A Primer on Traffic Safety*, Washington, D.C., 1993.
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IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 4

DELINEATORS

4.0 INTRODUCTION

Section 4 is concerned with chevron-alignment signs, post-mounted delineators, object markers, reflectorized flexible posts (tubular markers), and an innovative, internally illuminated guidance tube. All five types are particularly useful in guiding the driver through potentially hazardous areas at night and during rain and snow.

The first three are conventional delineators, meaning that they are light-reflective devices mounted *at the side of* the roadway to indicate changes in the horizontal alignment of the roadway.

Flexible posts are channelizing devices placed *on* the roadway to add emphasis to reversible-lane delineation, channelizing lines or islands.

The lighted guidance tube gives a continuous line of light that is helpful to drivers at confusing, unexpected curves.

4.1 CHEVRON-ALIGNMENT SIGNS

First introduced in Germany in 1940, the device was subsequently used, and experience with it was documented, in other European countries (1). It made its way across the Atlantic by the early 1970s. The *MUTCD* (2) considers it a type of warning sign and therefore shows it in Part II.

Chevron Alignment signs are placed on the outside of a curve, or sharp turn, in line with, and at right angles to, approaching traffic. They may be fabricated as large as indicated by an engineering investigation. Two should always be visible to a driver rounding the curve. To be effective, the signs should be visible for at least 500 feet. Therefore, where road curvature limits sight distance, trial runs may be needed to determine final location.

Note in the figure the back-to-back placement of the chevrons, to warn both directions of traffic.

4.2 EXAMPLE OF A CURVE LACKING CHEVRONS

The first figure shows a curve with a very narrow shoulder and a culvert headwall in the left foreground. The second makes it clear that a vehicle leaving the road on this curve could easily be guided by the sloping shoulder into a collision with the headwall. While Chevron Alignment signs would not remove the **hazard**, they would help to keep a driver, particularly a **distracted one**, on the road.

4.3 U.S. EXPERIENCE WITH CHEVRON ALIGNMENT SIGNS

In 1977 the Highway Division of the Oregon DOT published an evaluation of chevron directional guidance markers (3), as they had rejected various conventional object markers for this purpose. The report stated that one chevron equals in effectiveness three or more standard vertical delineators, and is less likely to be hit as it is larger and placed farther off the road. The report included several sets of photos, including these two figures, to illustrate the nighttime effectiveness of the markers.

Later that year the Georgia DOT published a similar report (1) in which they identified two specific areas of critical need for curve delineation. One was sharp curvature on urban freeways at interchanges; the other was curves sharper than six degrees in rural areas, particularly locations with sharp reverse curves. The report quoted other sources to the effect that the decision whether to accept a new delineator should be based on professional experience that considers both human factors and positive guidance. The report recommended application of chevrons to the numerous problem locations in the state, and called for the DOT to publicly endorse their use.

4.4 POST-MOUNTED DELINEATORS

Delineators are normally placed at a constant distance from the edge of the roadway. Two feet beyond the outer edge of the usable shoulder is an example location that allows the passenger door to be opened. They can be used on long stretches of roadway and on sharp curves. In the latter case, additional emphasis is desirable by supplementing the delineators with Chevron Alignment signs.

The first figure shows that they have some effectiveness at night, but that is limited by the small size of the reflector, only three inches, shown in the second figure. Also, they can be a maintenance problem, as they are easily and frequently knocked down by errant vehicles. They lose their reflectivity when splashed with mud.

4.5 OBJECT MARKERS AT AN OLD BRIDGE

The *MUTCD* identifies three types of object markers, which are used to mark obstructions within or adjacent to the roadway. The figure shows Type 3 object markers at the ends of the rail of an old bridge that lacks approach rail. The stripes must slope down toward the side of the obstruction where traffic is to pass.

4.6 OBJECT MARKERS ARE STILL NEEDED AT A MODERN BRIDGE

A more modern bridge, with approach rail, still needs object markers, as shown in the figure, because of the loss of shoulder width (4).

4.7 EXAMPLE OF DELINEATION AT AN OLD RAILROAD OVERPASS

For additional emphasis, a large surface such as a bridge pier may be painted with diagonal stripes, similar in design to the Type 3 object marker, as shown in the figure (4). A Type 3 object marker has been added in front of the right pier, with its inside edge in line with the inner edge of the obstruction.

Note the provision of a regulatory Keep Right sign, in lieu of an object marker, on the center pier. Below it is a Type 1 object marker of the “nine-button” style, used to help warn of an obstruction in the road. The figure also includes the required pavement markings to warn of approach to an obstruction.

4.8 REFLECTORIZED FLEXIBLE POSTS

The *MUTCD* notes that channelizing devices, including tubular markers (flexible posts), are sometimes used for general traffic-control purposes, outside of construction zones. A typical flexible post may be guaranteed to withstand 20 vehicular impacts: 10 at 55 mph and 10 at 35 mph. The figures show a flexible post and a group of them used to interrupt a long right-turn-only speed-change lane on a major arterial. The posts allow the residents of the complex to exit with greater safety. Various bases are offered for on-pavement installation, to mark islands, gore areas, construction zones, centerline medians and HOV lanes. Other bases permit the device to be installed in earth or concrete, for flexible roadside delineation, on- or off-ramps, curves, culverts, high-impact areas and obstructions.

4.9 LIGHTED GUIDANCE TUBES

An innovative delineator is shown in the figure (6). It consists of an optical lighting film housed in an all-weather, 4-inch-diameter polycarbonate tube. Each 100-foot length of tube is provided with a light source, and tiny prisms on the film reflect light and transport it evenly along the length of the section. The result is a continuous line of light that is visible from a great distance, giving drivers more time to react to sharp or confusing curves in construction zones and other “tight” locations.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 5

SIGNALS

5.0 INTRODUCTION

Most traffic signals are of the type that alternate the right of way. Traffic is alternately directed to stop and then permitted to proceed in what is called normal stop-and-go operation. These three-color devices are often called stop-and-go signals. Signal applications also include flashing beacons at stop-sign-controlled intersections, railroad crossing signals, and several other types. Of the 11 *MUTCD* warrants or justifications for installing a stop-and-go signal, one is based on a crash history of five or more collisions correctable by a signal (as are right-angle crashes), occurring in a year (1).

5.1 SAFE SIGNAL TIMING FOR PEDESTRIANS

Pedestrians should be allowed sufficient time to cross the street safely. Only about half of pedestrians understand the flashing DONT WALK, or upraised hand symbol, to be a pedestrian-clearance interval (2). Research has shown that concurrently timed pedestrian signals have no significant effect on pedestrian collisions, compared with the absence of any pedestrian signals (3). Many pedestrians seem to believe themselves “outside the law” governing obedience to traffic signals, crossing whenever it seems reasonably safe.

5.2 EDUCATING PEDESTRIANS TO UNDERSTAND THEIR SIGNALS

This sign may be installed above a pedestrian push button at high-pedestrian-use areas such as hospitals and schools (4). It is helpful to show a steady DONT WALK during the yellow and any red clearance, so that pedestrians will have an additional several seconds to get out of the street after the end of the flashing DONT WALK. This does not increase pedestrian clearance time, as the calculated clearance is displayed as the sum of flashing DONT WALK, yellow and any red clearance.

5.3 TEACHING PEDESTRIANS TO PUSH THE BUTTON

This sign, “Pedestrians MUST Push Button,” has been installed above every pedestrian signal in DeKalb County (Atlanta). Pushing the button will bring the WALK display at the earliest opportunity and will assure enough time to cross the street. Few pedestrians understand how dangerous it is to walk on a vehicular green when the pedestrian signal still shows a DONT WALK indication. They do not realize that a green long enough for one or two vehicles may be much less than that needed to cross the street on foot. Crossing on a DONT WALK indication could “trap” a pedestrian in the middle of the street when cross-traffic starts up.

5.4 SCHOOL CHILDREN MAY NEED A CROSSING GUARD

Traffic signals are not necessarily a positive protection for school children. In some circumstances, signal control at a school crossing requires supplemental control by an adult guard or school safety patrol. The Institute of Transportation Engineers recommends that students in grades K-4 not be allowed to cross major streets alone; an adult crossing guard or safety patrol should be provided (5).

5.5 YELLOW TIME SHOULD BE DESIGNED FOR THE APPROACH

The *MUTCD* calls for yellow intervals within a range of approximately 3 to 6 seconds. However, that does not mean that any value in that range will do. The yellow time needs to be tailored to each individual approach. Intersection-specific conditions, such as truck usage, should be taken into account. Generally the longer intervals are appropriate to higher approach speeds. The table shows yellow intervals calculated for a range of approach speeds and slopes, following a rational formula given in the *Traffic Control Devices Handbook* (6). Excessively long yellow intervals may encourage driver disrespect, so a maximum yellow time of 5 seconds is commonly adopted. If the table calls for more, the excess over 5 is timed as red clearance, discussed next.

5.6 YELLOW IS NOT A CLEARANCE INTERVAL

In most states it is not intended that the yellow be long enough to clear the intersection. The yellow times in the table are just long enough for the clearing vehicle (Vehicle A in the figure) to barely enter the intersection. If Vehicle B immediately receives the green, there could be a collision, especially if the intersection is wider than the one in the figure.

5.7 CONSIDER ADDING AN OPTIONAL RED-CLEARANCE TIME

Since the yellow is not a clearance interval, the *MUTCD* states “The yellow vehicle change interval may be followed by a red clearance interval, of sufficient duration to permit traffic to clear the intersection before conflicting traffic movements are released” (1). The figure shows the scenario when red clearance time is added to the yellow. This scenario is safer than the one in the preceding figure (7). Considering older drivers, the FHWA has called for red clearance intervals to be “consistently implemented” (8).

5.8 RED-CLEARANCE TIMES DESIGNED TO CLEAR THE INTERSECTION

The table shows red clearance times long enough to clear the intersection before cross-traffic released on a green signal. Wide intersections on low-speed routes are critical.

5.9 A GREEN-ARROW PHASE MAY NEED TO BE “PROTECTED ONLY”

Once the decision is made to protect a left-turning movement with a green-arrow phase, it must be decided whether the turn can also be safely permitted at another time during the signal cycle, on a permissive green ball, or instead must be prohibited for safety by a red indication whenever the left-turn arrow is not on. The former is called protected-permissive phasing and the latter is known as protected-only phasing. The figure shows the signals used with a protected-only design. Protected-permissive phasing is normally preferred to protected-only, to maximize capacity and efficiency, unless safety requires protected-only phasing. References 9 and 10 should be consulted for lists of hazardous conditions that indicate the need for protected-only phasing. Some of these are high speeds; the presence of three or more oncoming through lanes for the left-turning vehicles to cross; double left-turn-only lanes; and inadequate sight distance for turning drivers to be able to see the required 5-second gap between oncoming through vehicles. For older drivers, the FHWA has called for protected-only operation to be used “except when, based on engineering judgment, an unacceptable reduction in capacity will result” (8).

5.10 CONSIDER PREEMPTION FOR EMERGENCY VEHICLES

In one year, the City of Houston, Texas receives almost 300,000 calls for medical assistance. Their firemen make almost 60,000 runs. Life and property are at stake, so there is great interest in speeding emergency vehicles through signalized intersections. The *MUTCD* provides for traffic signals to be modified in timing, sequence or display to grant “priority control” or “preemption” to certain classes of vehicles. Preemption must not shorten or eliminate yellow intervals, but pedestrian clearance intervals may be abbreviated in order to bring the green sooner to these vehicles, whose lights and/or sirens usually alert pedestrians to clear the way. Modern preemption techniques are designed to keep traffic moving; long all-red periods or flashing sequences are no longer used.

5.11 RAILROAD GRADE-CROSSING PREEMPTION

In 1995 the attention of traffic engineers nationwide was captured by a tragedy in the village of Fox River Grove, Illinois. Seven high-school students were killed when their school bus was struck by a train while stopped at a signalized highway-rail crossing. The ensuing USDOT task force report, titled “Accidents That Shouldn’t Happen”(11), focused attention on the hazard where the tracks are so close to a parallel arterial highway that there is insufficient clear space to store a design vehicle between them. The profession saw that the concern needed to extend to locations where queues of vehicles stopped on a red signal during congested periods could extend back hundreds of feet to the tracks. An ITE paper described a pre-signal to control traffic approaching the railroad crossing and the intersection, to help prevent a design vehicle from being forced to stop on the tracks during red intervals (12).

5.12 SAFETY BENEFITS OF COORDINATION

Signal coordination can allow platoons of vehicles to pass through signal after signal on the green, significantly reducing stopping and the resulting delay and potential for rear-end collisions. Some case studies have been documented. In the early 1970s the Stadium-Area Signal System Project in Atlanta placed 21 signalized intersections under the new central-computer-based system. The probability of having to stop at any one intersection was reduced by 60 percent. A study of police crash reports, before and after the improvement, showed that crash frequency dropped 38 percent (13).

5.13 “FREE” ACTUATED OPERATION INSTEAD OF PROGRAMMED FLASH

For flashing yellow/red operation to be appropriate, minor-street drivers need to have an unrestricted view of approaching main-street traffic, and main-street volumes need to be low (6). Much of the need for programmed flash can be eliminated by running shorter cycles during low-volume periods. Cycles can be shortened by omitting protected left-turn arrows by time of day. Even shorter cycles can be gotten by eliminating coordination during light-traffic periods; the signals can run “free” in a fully actuated mode.

5.14 OCCURRENCE OF MALFUNCTION FLASH SHOULD BE MINIMIZED

Traffic-signal cabinets include a monitor unit, shown in the figure, that oversees the electricity sent from the signal equipment over the field wiring to the signal heads. If conflicting greens are energized simultaneously (because of a malfunction), the monitor immediately causes the signals to go to flashing operation, usually yellow/red, to avert a right-angle crash. At present it is not clear how to manage malfunction-flashing operation where sight distance is deficient or main-street volume is high. A reasonably safe solution should be found for each such location. For example, the signal status could be monitored continuously from the signal shop; when flashing operation is detected, a traffic-control police officer (and the signal-repair crew) could be dispatched to the intersection (14).

5.15 GOOD MAINTENANCE OF SIGNALS IS IMPORTANT

Improper maintenance, or the lack of it, or the failure of a timely response to malfunctions, is hazardous and constitutes a serious legal threat to an agency and its personnel (15). The *MUTCD* lists the duties of the responsible maintaining agency, such as having properly skilled maintenance available without undue delay for all emergency calls, including lamp failures, and providing stand-by equipment to minimize the interruption of signal operation due to equipment failure. The International Municipal Signal Association offers programs for the training and certification of maintenance technicians (16).

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IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 6

SOME OPERATIONAL SAFETY IMPROVEMENTS

6.0 INTRODUCTION

This section discusses operational measures to improve safety at certain specific locations. These include neighborhoods where residents call for “traffic calming” to reduce a cut-through problem; hazardous shoulder drop-offs; highway curves where drivers need positive guidance for safety; and narrow roadway sections and bridges. (Locations with obstructed sight distance are given the entire Section 7).

6.1 TRAFFIC CALMING

Increasing traffic volumes on arterials are shifting drivers onto neighborhood streets, resulting in a decline in quality of life for the residents. This has led to an increasing number of citizen requests to “calm” the traffic in their neighborhoods. Traffic calming probably cannot reduce cut-through volume, but can reduce speed, thereby reducing the severity of crashes. Some speed-reduction schemes are inadvisable. The *MUTCD* recommends that “. . . STOP signs should not be used for speed control”(1). Also, “Because the STOP sign causes a substantial inconvenience to motorists, it should be used only where warranted.” If used to excess, regulatory and warning signs tend to lose their effectiveness and breed disrespect for traffic control devices in general. Reference 2 provides additional ammunition against STOP-sign-use for speed control and is an excellent “toolbox” of effective calming devices.

6.1.1 SPEED HUMPS DO REDUCE SPEED

A speed hump is an asphalt mound of pavement that extends the full width of a two-lane, local, residential street. Speed humps are 3 to 4 inches in height and have a travel length of 12 feet. They have been widely used since 1993, when the Institute of Transportation Engineers published a summary of proposed recommended guidelines for their use (3). The figure shows an Atlanta example. Experience has shown that speed humps reduce average speeds a little, while the highest speeds drop a lot. Like STOP signs, speed humps control speeds only at one spot. To reduce speeds along an extended length of street, a series of humps usually is needed.

6.1.2 SPEED HUMPS ARE EFFECTIVE BUT HAVE DRAWBACKS

Adequate signing and marking of speed humps is essential to warn drivers of speed hump presence and to allow drivers the time and distance needed for proper response. So many signs and markings along a residential street may be objectionable from an aesthetic point of view. Also, in 1998 the Georgia DOT announced that no funds in the Local Assistance to Roads Program will be used to repave any streets that have speed humps (4). Some believe that speed humps are traffic control devices, because they are intended to

regulate traffic speed and volume. They reason that any traffic control device must be in conformity with the Georgia *MUTCD*, which makes no mention of speed humps. Therefore the legality of speed humps has been questioned by some authorities.

6.1.3 CAN SPLITTER ISLANDS CALM THE TRAFFIC?

This new “splitter” island has temporary barrels to alert drivers to the obstruction to traffic. The landscaping on the island is intended to break the sight distance along the road, forcing drivers to slow down. Whether or not the island reduces speeds or influences driver behavior in any other way, it is an attractive addition to the entrance to a neighborhood and gives an unmistakable cue to the driver that this is a residential street.

6.2 PAVEMENT-EDGE DROP-OFFS

In 1987 the Transportation Research Board determined that pavement-edge drop-offs are more hazardous than previously thought, and that they are a common source of tort claims against highway agencies and contractors. Vertical or near-vertical pavement-edge drop-offs of 2 inches or more can cause a vehicle to go out of control, producing what some call a “sling-shot” swerve across the centerline into oncoming traffic (5).

6.2.1 SCRUBBING REENTRY CAUSES THE PROBLEM

The loss of control is due to “scrubbing reentry,” which can occur if the inner casings of the right tires are rubbing against the edge-face, as shown in the figure (6). When the driver first cuts the wheel to the left, the vehicle fails to remount the pavement, as at first the force on the tire is more lateral than vertical. Over several seconds, the driver keeps turning the wheel to the left, until the vehicle abruptly remounts the pavement. The vehicle yaws to the left, then the right rear wheel remounts, and the vehicle quickly veers across the centerline before the driver can regain control.

6.2.2 A VERTICAL EDGE-FACE IS ESPECIALLY HAZARDOUS

Erosion produced this 4-inch-deep rut in Iowa. When the right wheels of an errant vehicle dropped into this rut, the driver lost control, crossed the centerline of the roadway, and was killed in a head-on collision with an oncoming car. Note that this is a Portland cement concrete pavement, which of course will have a vertical edge-face, with little or no rounding where the edge-face meets the pavement surface. A vertical edge-face is especially hazardous, as shown next.

6.2.3 HAZARD DEPENDS ON SPEED AND HEIGHT AND SHAPE OF DROP-OFF

A 1985 research project produced this figure, indicating that the tolerable pavement-edge drop-offs decrease with increasing speed and as the edge face approaches vertical (7). The values in the figure assume ordinary drivers (not professional test-drivers) and passenger cars and pick-up trucks. Tractor-trailer trucks and motorcycles might need smaller drop-offs for safety.

6.2.4 LARGE DROP-OFFS CAN CAUSE OVERTURNING

Drop-offs over 5 inches usually cause overturning, due to drag forces on the vehicle's undercarriage. This 12-inch drop-off in South Carolina was followed by an immediate 6-inch rise. A car that left the road at this location was caused to flip end over end.

6.2.5 A WEDGE OF STABLE MATERIAL GIVES A TEMPORARY FIX

In addition to placing low-shoulder warning signs, drop-offs should be corrected to provide sufficient stability for an errant vehicle. A fillet or wedge of stable material, as in the figure, is an effective temporary remedy until the entire shoulder can be rebuilt (8).

6.2.6 INADEQUATE CORNER RADIUS CAN PRODUCE HAZARDOUS HOLES

Intersections should be designed with a corner radius for pavement adequate for the larger vehicles expected. If the radius is too small, the right-rear wheels of right-turning vehicles will go off the pavement, and will soon produce a hazardous rut or "hole," especially in wet weather when the turf shoulder is soft. This 6.5-inch-deep hole was at a South Carolina intersection. A teen-age driver approaching at speed somehow allowed the car to drift off the road. It went out of control; a head-on collision killed both drivers.

6.3 ROADWAY CURVES

The most common roadway curve defect is a sharp curvature with deficient warning and/or delineation, sometimes hidden by a hillcrest (5). (Sight obstructions are covered herein in Section 7, titled "When Sight Distance is Limited"). Section 4, titled "Delineators," discussed the use of Chevron Alignment signs and post-mounted delineators to help drivers to negotiate curves safely. This section builds on that material, describing the Curve sign and the Advisory Speed plate that may be placed under it. The wording of the *MUTCD* is permissive: "The Curve sign may be used . . . The plate may be used . . ." No requirement for design or application is intended.

6.3.1 DETERMINING THE "RECOMENDED SPEED" OR "SAFE CURVE SPEED"

The *MUTCD* refers to the use of engineering investigations of roadway, geometric and operating conditions to determine the "recommended speed," sometimes called the safe curve speed, or the advisory speed (1). This speed is much lower than the "critical speed," at which skid or rollover occurs. It is a conservative, comfortable speed that can be exceeded somewhat without disaster. The *Traffic Control Devices Handbook* explains several ways to determine the recommended speed (8). The "ball-bank indicator" device, shown in the figure, is often the easiest, as it avoids having to determine the radius or the superelevation of the curve.

6.3.2 USING THE BALL-BANK INDICATOR

The ball-bank indicator has been adopted by Georgia and many other states as an approved device for determining the recommended speed on a curve. The black ball shown in the figure can slide in a liquid-filled tube to a point of equilibrium that depends on the banking of the curve and the centrifugal force on the vehicle as it rounds the curve. That is, the black ball swings out just as if it were a pendulum hanging from the ceiling of the vehicle. To use a ball-bank indicator, first a test vehicle with ordinary suspension is driven onto a level place, such as a garage floor. The device is mounted level on the dashboard or windshield, so that it reads zero. Then the curve is driven repeatedly, each time at a different constant speed 5 mph faster than the previous run. An observer accompanying the driver records the degree-reading for each run. The recommended safe speed is conventionally determined from the figure (5). For example, if a reading of 14 degrees is obtained at a speed of 15 mph, then that is the safe speed. A reading of 12 degrees at 25 mph means that 25 mph is the safe speed. A reading of 10 degrees at 40 mph means that 40 mph is the safe speed (8).

6.3.3 ARE CURRENT BALL-BANK CRITERIA TOO CONSERVATIVE?

Positive-guidance literature has cited overly conservative advisory speed plates on curve-warning signs as prime examples of over-restrictive practices that reduce the credibility of warning signs in general (9). Recent research suggests that advisory speeds on curves are generally set too low and are not set consistently from state to state or even within a given state (10). This project concluded that current ball-bank criteria result in very low and unrealistic speeds. It was recommended that the current criteria should be revised upward, as shown in the figure, to better reflect average curve speeds.

6.4 NARROW BRIDGES

Two crashes at narrow bridges in Texas and New Mexico in the late 1960s prompted a Congressional request to the FHWA to develop short-range, low-cost measures to reduce crashes at such locations.

6.4.1 POSITIVE GUIDANCE

The FHWA responded by developing in 1973 the Positive Guidance concept, which combines highway/traffic engineering and human factors methods and procedures to help produce a highway information system matched to driver limitations and situation demands. Positive Guidance was introduced herein in Section 1. Today, Positive Guidance procedures are applied to a variety of situations, not just to narrow bridges..

6.4.2 SIGNING AND MARKING THE APPROACH TO A NARROW BRIDGE

The Narrow Bridge sign is intended for use in advance of a bridge or culvert having a clear two-way roadway width of 16 to 18 feet, or any bridge or culvert having a roadway clearance less than the width of the approach pavement. Additional protection should be provided by the use of object markers, delineators, and pavement markings (1). The figure shows a suggested design with the first Narrow Bridge sign one-half mile from the bridge and a second one 500 m (1500 feet) from it (11).

6.4.3 SIGNING AND MARKING THE APPROACH TO A ONE-LANE BRIDGE

The One Lane Bridge sign is used on two-way roadways in advance of bridges and culverts having a) a clear roadway width of less than 16 feet; or b) a clear roadway width of less than 18 feet when trucks are a high proportion of the traffic; or c) a poor alignment on the approach to a structure having a clear roadway width of 18 feet or less. Additional protection should be provided by the use of object markers, delineators and pavement markings (1). The figure shows a One Lane Bridge sign one-half mile from the bridge, another 1500 feet from it, and a Signal Ahead sign (12).

6.5 REFERENCES FOR SECTION 6

1. U.S. Department of Transportation, *Manual on Uniform Traffic Control Devices*, Washington, D.C., Federal Highway Administration, 1988.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 7

WHEN SIGHT DISTANCE IS OBSTRUCTED

FIGURE
7.1.3A



FIGURE
7.1.3B

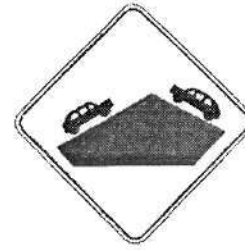


FIGURE
7.1.4



FIGURE
7.1.5



WHEN SIGHT DISTANCE IS OBSTRUCTED...

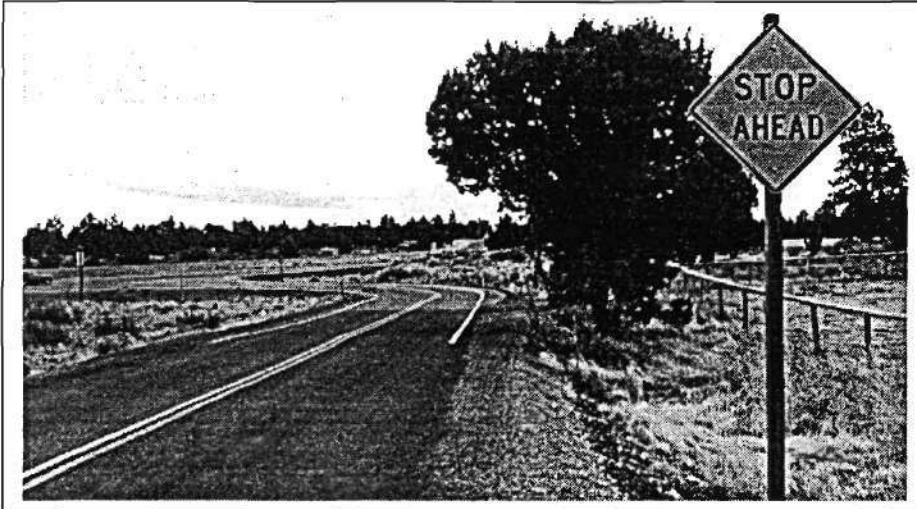


FIGURE 7.2

Posted or 85 Percentile Speed, mph	Setback of STOP AHEAD Sign, feet
30	100
40	225
50	375
60	550

FIGURE 7.2.1

85 Percentile Speed, mph	Minimum Visi- bility Distance, feet
20	175
30	270
40	390
50	540
60	715

FIGURE 7.2.2



FIGURE 7.2.3A

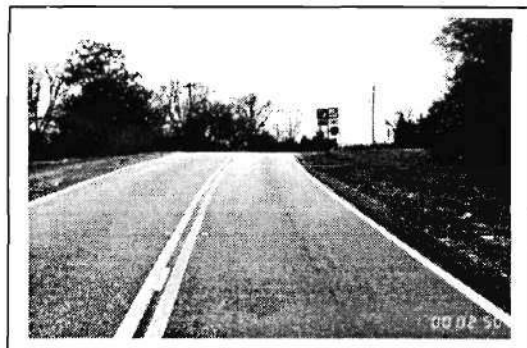


FIGURE 7.2.3B

WHEN SIGHT DISTANCE IS OBSTRUCTED...

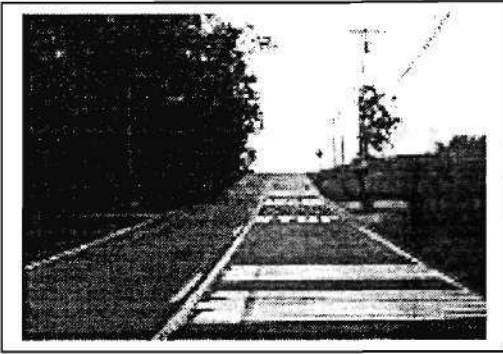


FIGURE 7.2.4A

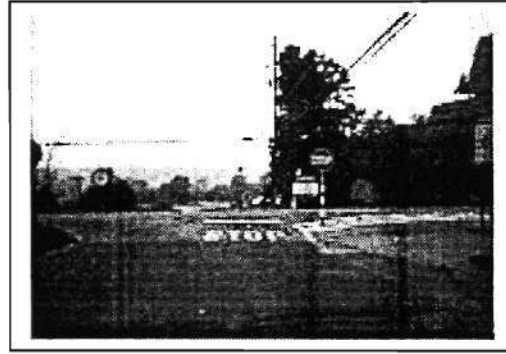


FIGURE 7.2.4B

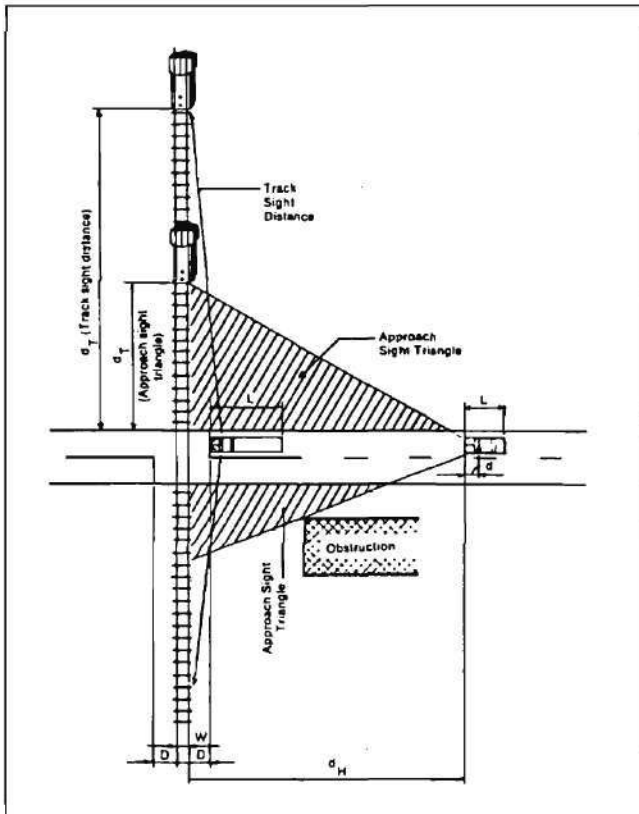


FIGURE 7.4

FIGURE 7.4.1

Train Speed, Mph	Vehicle Speed, mph			
	0	20	40	60
	Distance d_T Along Railroad From Crossing, ft.			
20	480	210	210	245
40	960	415	415	490
60	1440	620	620	735
80	1920	830	830	980
	Distance d_H Along Highway From Crossing, ft			
	N/A	135	340	660

WHEN SIGHT DISTANCE IS OBSTRUCTED

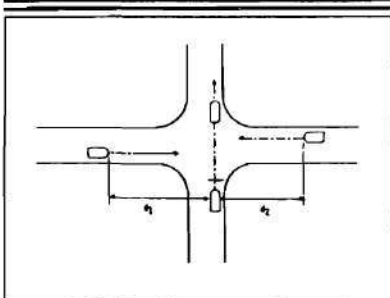


FIGURE 7.5A

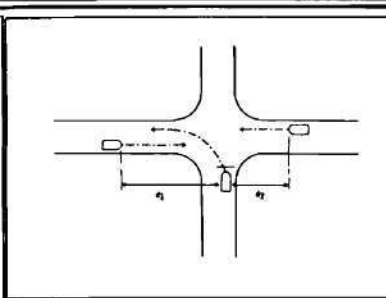


FIGURE 7.5 B and C

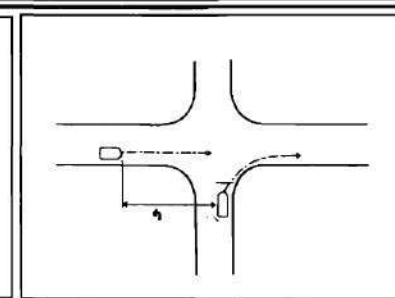
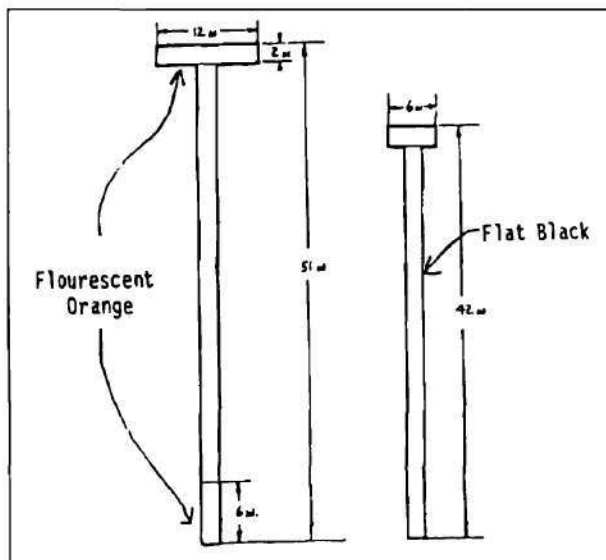


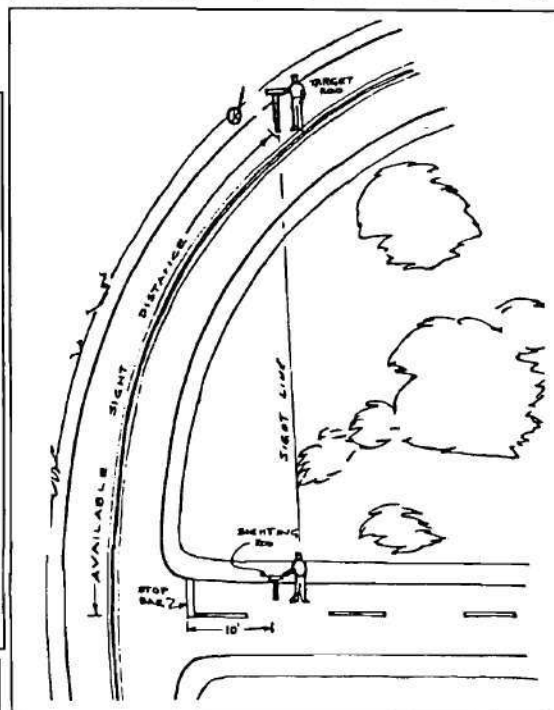
FIGURE 7.5D

	Case A	Case B	Case C	Case D
Design Speed, Mph	Crossing Roadway From Stop, Feet	Turning Left Across Path of Vehicle Approaching From Left, Feet	Turning Left Into Path of Vehicle Approaching From Right, Feet	Turning Right Into Path of Vehicle Approaching From Left, Feet
70	670	710	1560	1560
60	570	610	1150	1160
50	470	510	840	840
40	380	410	570	570
30	290	310	370	370

FIGURE 7.5.1



FIGURES 7.5.2 A and B



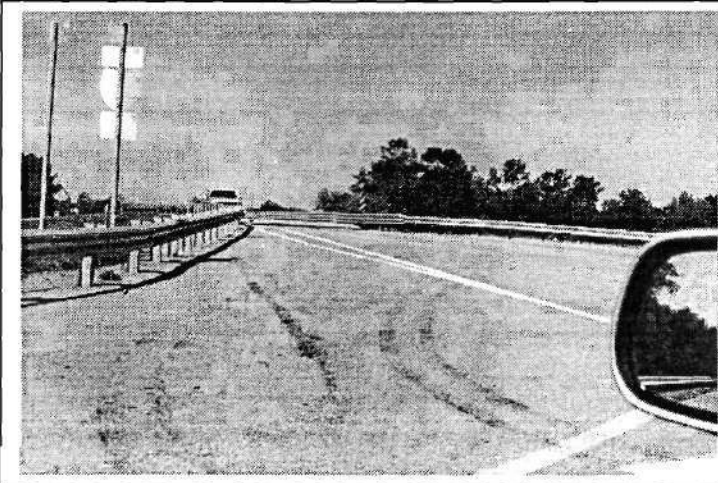


FIGURE 7.5.3

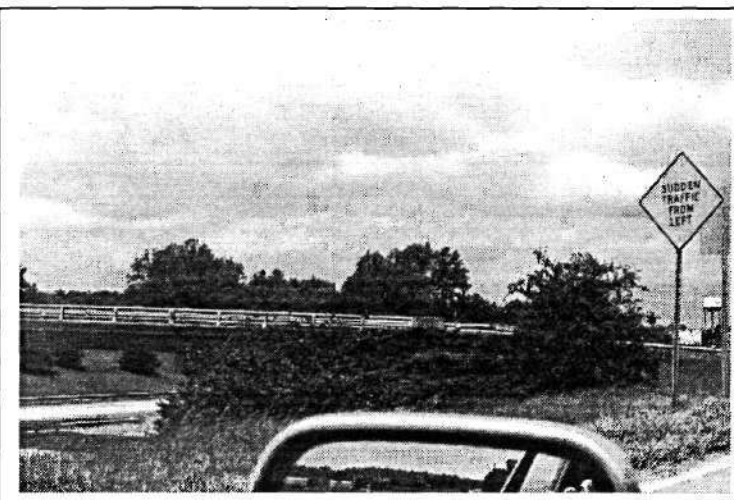


FIGURE 7.5.4



FIGURE 7.5.5A



FIGURE 7.5.5B

7.6 REFERENCES FOR SECTION 7

1. American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990.
2. USDOT, Federal Highway Administration, Office of Traffic Operations, *Positive Guidance in Traffic Control*, Washington, D.C., 1975, p.16.
3. Freedman, Mark, L.K. Staplin and Lawrence E. Decina, "Limited Sight Distance Warning for Vertical Curves," *Public Roads*, Vol. 49, No. 2, September, 1985, pp. 46-53, quoted in Bowman, Brian, Reference 4, p. 26.
4. Bowman, Brian L., *Supplemental Advance Warning Signs*, Synthesis of Highway Practice 186, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 1993.
5. American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1984, p. 48.
6. U.S. Department of Transportation, *Manual on Uniform Traffic Control Devices*, Washington, D.C., Federal Highway Administration, 1988.
7. Matson, Theodore M., Smith, Wilbur S. and Hurd, Frederick W., *Traffic Engineering*, McGraw-Hill, New York, 1955.
8. McShane, William R., Roess, Roger P. and Elena S. Prassas, *Traffic Engineering*, 2nd Ed., Prentice Hall, New Jersey, 1998, p. 378 ff.
9. Federal Highway Administration, *Railroad-Highway Grade Crossing Handbook* - 2nd Edition, Report No. FHWA TS-86-215, Washington, D.C., 1986, p. 131.
10. USDOT, Federal Highway Administration, *Local Highway Safety Studies, Users' Guide*, Washington, D.C., 1986.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 8

PEDESTRIAN AND BICYCLIST SAFETY

8.0 INTRODUCTION

Pedestrians and bicyclists are increasingly being considered in planning and design. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 gave transportation officials a new mandate to consider alternatives to the single-occupant motor vehicle in their planning. The TEA-21 legislation enacted by Congress in 1998 provided for a significant increase above ISTEA in the funds available for improvements aimed at pedestrians and bicyclists. The figure is from the National Bicycling and Walking Study (1).

8.1 CHARACTERISTICS OF PEDESTRIAN COLLISIONS

The number of fatal pedestrian collisions has dropped from 9,000 in 1969 to 5,472 in 1994 (2). They represented about 13 percent of total 1994 traffic fatalities. Over two-thirds (71 percent) of pedestrian fatalities occur in urban areas. Most (62 percent) occur at night. Almost 70 percent of the pedestrian fatalities are males; their fatality rate per 100,000 population is more than twice the rate for females. Most (80 percent) pedestrian fatalities occur at non-intersection locations. Two-thirds of pedestrian fatalities involve improper crossing of the roadway or intersection, or walking, playing, working or standing in the roadway.

8.2 THE MID-BLOCK "DART-OUT" IS THE MAJOR COLLISION TYPE

One third of all pedestrian collisions are of the "dart-out" type, in which the pedestrian rushes into the street in the middle of a block and either runs into or is hit by a moving vehicle (2). The majority of pedestrians are struck in the near lane. This type of collision occurs most often in residential neighborhoods. Factors involved tend to be intoxication of the pedestrian or driver and the failure of the pedestrian to search for traffic and to yield the right of way. Sometimes the pedestrian is not visible (sight-obstructed or inconspicuous because of dark clothing).

8.3 THE VEHICLE TURN-MERGE IS ALSO A SIGNIFICANT TYPE

Eleven percent of all pedestrian collisions are of the "vehicle turn-merge" type, in which the driver is turning into and merging with traffic (2). The pedestrian is usually walking in a direction that is different from the driver's focus of attention. The driver may be looking the other way or have an obstructed view of the pedestrian. The driver errs in failing to search for and detect the pedestrian, while the pedestrian fails to search for vehicles and may fail to dress conspicuously.

8.4 SIDEWALKS HEAD THE LIST OF PHYSICAL COUNTERMEASURES

Pedestrian collisions are a complex problem with no easy solution. Improvement requires better education of pedestrians, enforcement of existing laws and ordinances aimed at drivers and pedestrians, the wearing of retroreflective clothing at night, as well as engineering and physical measures. Heading the list of the latter solutions are sidewalks, which have been shown to significantly reduce the number of pedestrian collisions in residential and business areas (3).

8.4.1 GUIDELINES FOR INSTALLING SIDEWALKS

Sidewalks should be considered in the design of new streets and in improvement of existing streets. Factors that should be considered in reserving space for sidewalks include type of abutting land use, amount of pedestrian activity, speed and volume of traffic on the street, and proximity to facilities such as schools, libraries and parks (4). A 1987 FHWA study gave recommended general sidewalk requirements, shown in the table (5). The requirements depend on land use, roadway functional classification and, in the case of residential areas, dwelling-unit density. A footnote in the table calls for a sidewalk on at least one side of any local street within two blocks of a school site that would be on a walking route to school. The regulations of your locality need to be checked, as they may call for an even higher standard, such as sidewalks within one mile of an elementary school. The width of a sidewalk should depend on where it is installed and the anticipated usage. Widths of 4 to 6 feet are appropriate for most sidewalks. A 6-foot width should be considered in areas with frequent pedestrian travel, such as near schools, parking facilities, and transportation terminals (4).

8.5 CONSIDERATION OF DISABLED AND ELDERLY PEDESTRIANS

Disabled persons and older adults may require consideration of sidewalk-related facilities such as curb ramps, guidestrips, handrails, widened sidewalks and careful placement of street furniture. Guidestrips are raised markings of sand, gravel or glass beads cemented to the surface of a crosswalk or the edge of a sidewalk. They can be felt by a blind person with a cane and used as a guide. Handicapped pedestrians may also require signal-related improvements such as audible pedestrian signals and longer WALK and FLASHING DONT WALK intervals. Special signs may be needed to warn drivers of the possible presence of blind or deaf pedestrians (3).

8.6 BUS-STOP RELOCATION FOR PEDESTRIAN SAFETY

The figure shows a near-side bus stop and a far-side one. Buses stopped on the near side of intersections may severely block the pedestrians' view of approaching traffic, and the approaching driver's view of pedestrians entering the street in front of a bus, where the drivers are often unable to stop for them. A stop for transit buses or school buses should be moved from the near side to the far side of an intersection, in order to eliminate the sight restriction posed by the bus (3).

8.7 PEDESTRIAN BARRIERS ALONG SIDEWALKS OR ROADSIDES

It is axiomatic that a physical separation of pedestrians and vehicles is desirable for safety. Fences or railings such as in the figure (6) can improve pedestrian safety at intersections or mid-block locations, by impeding their crossing at hazardous locations.

8.8 LIGHTING FOR PEDESTRIAN SAFETY

Overhead illumination is usually installed in urban areas to aid drivers at night and to deter crime. However, pedestrian safety is a significant side-benefit. Most pedestrian fatalities occur at night. Research has shown that pedestrians at well lit locations choose larger gaps for crossing. Improved lighting can reduce pedestrian collisions at night by almost one-half (6).

8.9 PEDESTRIAN-RELATED SIGNS

The *MUTCD* (7) describes pedestrian-related regulatory signs such as WALK ON LEFT FACING TRAFFIC, NO TURN ON RED, warning signs including WATCH FOR TURNING VEHICLES, and guide signs, such as PUSH BUTTON FOR WALK SIGNAL. The signs shown will command greater respect and compliance if it can be made evident to the pedestrian why it is hazardous to cross here.

8.10 MARKED CROSSWALKS

It was pointed out in Section 3 that the "Ladder" design of crosswalk markings is much more visible to the approaching driver. It and the "Zebra" design, shown, are commonly used for crossings at hospitals, airport terminals, and other locations with heavy pedestrian activity. Crosswalk markings are particularly recommended at signalized intersections with pedestrian signals and at locations where a school-crossing guard is normally stationed to assist children to cross the street (5).

8.11 TRAFFIC CONTROLS FOR BICYCLE FACILITIES

Part IX of the *MUTCD* describes signs and markings related to bicycle use, for application on highways or bikeways. The figure is from the *MUTCD* and shows many details of the designation of highway bicycle lanes, including the design at intersections where vehicles have turn-only lanes (7). Bicycle lanes must be developed for one-way operation; two-way operation on one side of the street is not recommended for several reasons enumerated in Reference 4.

8.12 DETECTION OF BICYCLES AT SIGNALIZED INTERSECTIONS

The Quadrupole loop-detector configuration shown in the figure is one of the best for detecting bicycles to actuate intersection traffic signals, provided the figure-8 pattern shown at the bottom of the diagram is wound two times to give a double layer design ("2-4-2"), and provided the bicyclist rides close enough to the center wires (8). Positive detection of bicycles at signalized intersections is important, so that bicyclists will not feel it necessary to endanger themselves by running the red.

8.12.1 BICYCLE-DETECTOR SIGNS AND MARKINGS IN ATHENS, GEORGIA

Athens/Clarke County, home of the University of Georgia, has long used unique pavement markings and signs to induce bicyclists to stop on an 11-foot-long broken white stripe in order to be detected (8).

8.12.2 ANOTHER SPECIAL BICYCLE PAVEMENT MARKING

The City of San Luis Obispo, California mounted an aggressive public information program to inform bicyclists that they could be detected and make the red light turn green by traveling over the pavement markings shown in the figure.

8.13 TYPICAL SECTION FOR A BIKE PATH

The figure shows the City of Madison, Wisconsin's typical section for a bike path. Unlike bicycle lanes on streets, bike paths are designed for two-way operation.

IMPROVING OPERATIONAL SAFETY ON LOCAL ROADS AND STREETS

SECTION 9

IDENTIFYING LOCATIONS WITH IMPROVEMENT POTENTIAL

IDENTIFYING LOCATIONS WITH
IMPROVEMENT POTENTIAL

FIGURE 9.0

THE "PINK SLIP" PROGRAM IN
OAKLAND COUNTY, MICHIGAN

FIGURE 9.1



FIGURE 9.2.A

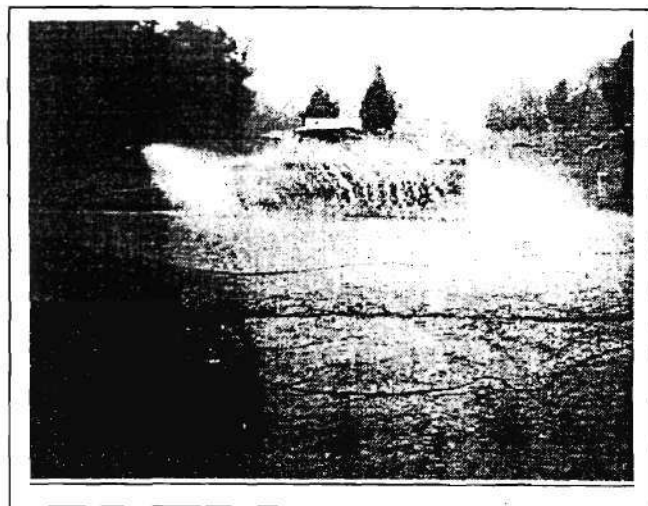


FIGURE 9.2.B

9.3 ENGINEERING ASSISTANCE FROM OUTSIDE THE AGENCY

The *MUTCD* states "Qualified engineers are needed to exercise the engineering judgment inherent in the selection of traffic control devices, just as they are needed to locate and design the roads and streets which the devices complement. Jurisdictions with responsibility for traffic control that do not have qualified engineers on their staffs should seek assistance from the State highway department, their county, a nearby large city, or a traffic consultant." Agency personnel should take the time to develop a network of contacts in other agencies to whom they can turn for advice and assistance.

9.4 POLICE AND SHERIFFS HAVE VALUABLE INFORMATION

An agency responsible for roads and streets should maintain close contact with the local police or sheriff, as they have first-hand, day-to-day experience investigating the crashes that occur in that jurisdiction. Is there a procedure for the local public works department to learn quickly of the occurrence of crashes and to receive a copy of each police report? If the police are aware of a road hazard, such as a drainage problem causing water to be on the road during a rainstorm, will the road agency be notified by them in a timely way? When the road agency responds right away to such notifications by the police, that prompt action will reinforce the willingness of the police to go to the trouble of calling.

9.5 TABLES OF EXPECTED VALUES

Intersection-crash data for several years in the early 1990s were collected from several major urbanized areas in Georgia, including the Atlanta, Savannah and Macon areas (2, 3, 4). The data were processed statistically and organized into tables of "expected values." The purpose of the tables is to allow an intersection to be quickly analyzed to determine if it has an abnormally high frequency of crashes, in which case it would be targeted for further study as an intersection with potential for improvement.

There were separate tables developed for signalized and unsignalized intersections, those with three legs and four legs, and separate tables for various entering volume ranges, such as average daily traffic (ADT) ranges of 0-10,000, 10,000-20,000, etc. For many types of crashes (right-angle intersecting, rear-end, etc.), there was a calculation of the average number of such crashes per year, and the 90th and 95th percentile number of crashes. (That is, only five percent of the intersections had more crashes per year than the 95th percentile). The figure shows an excerpt from the table for the Savannah area that is for 4-legged, signalized intersections with total entering volumes between 20,000 and 30,000 vehicles per day. Such tables are very easy to use, as they require no calculation of crash rate, that is, no calculation of a certain number of crashes per million entering vehicles.

9.5.1 EXAMPLE OF THE USE OF TABLES OF EXPECTED VALUES

Suppose that in the Savannah area there is a 4-legged, signalized intersection that carries a total entering volume of 24,000 vehicles per day. The location is experiencing 20 right-angle crashes per year, and it is desired to determine whether this is so high a number that action should be taken to try to improve the safety at this intersection. At a volume level of 24,000 vehicles per day, this location lies within the range of the table in the figure.

The table shows that the average number of right-angle crashes expected at such a site is 6.7. The 90th percentile is seen to be 13.0, meaning that only 10 percent of such sites have more than 13 right-angle crashes per year. Our intersection, with 20 such crashes, is above the 90th and above even the 95th percentile, 18.6. It stands out as abnormally high, particularly if the 20 is the average of several years of data. The 20 is so high that it probably cannot be attributed to the normal variation that will be found from intersection to intersection in that volume range. Instead, it may be due to an intersection-specific problem that might be correctable by operational improvement.

Additional studies should be conducted at the intersection to determine probable causes of the right-angle-crash problem and to identify appropriate countermeasures. For example, it might be found that the yellow interval needs to be lengthened, and/or a red clearance interval needs to be added.

9.5.2 A COMPLETE SET OF TABLES IS IN APPENDIX

An appendix to this notebook includes a complete set of “expected values” tables for signalized and unsignalized, 3-legged and 4-legged intersections over a wide range of volumes. The set in your notebook is from the urban area nearest your locality. These tables have proven to be useful for a variety of practical purposes.

9.6 END OF THE ROAD

This course is but one component of Georgia’s Local Technical Assistance Program (LTAP), brought to you by the Georgia Department of Transportation. We hope that this course has been helpful to you and worth your taking the time away from your normal duties. Your completing the Course Evaluation form will help us to bring to you future programs that will enhance **your** job skills and further your professional development.

Improving Operational Safety on Local Roads and Streets

INSTRUCTOR'S GUIDE

This Guide is based on the experience of seven presentations around Georgia in February, 2000, as explained in the Final Report. The presentation was developed as a "one-day" course, meaning six or seven hours. However, the realities of the LTAP program are that time must be allowed for the participants to travel from their workplace to the presentation site in the morning, and to return in the afternoon, all within the normal working day. Therefore, the course does not begin until 9:00 a.m. and must close by 3:45 p.m. After deducting two 15-minute breaks, you will have only five hours for actual instruction.

In five hours you will be able to cover the nine sections of the notebook only if there is minimal discussion and certain videos are cut short, as explained below. While cutting certain videos short will surely be found desirable, the author suggests that it is preferable that the participants feel free to enjoy a full discussion, and that the presenter deviate from the notebook in order to give examples from his/her own experience, even if that means finishing only six or so of the sections. The presenter can return some other day.

It seems a good idea to arrive at the presentation site an hour before the course is to begin, so that you may be able to settle into the classroom before the participants arrive. Time is needed for the computer projection and the video display can be set up.

Once you have been introduced, and you have expanded a bit on the introduction to explain your background in traffic operations, the next step is to ask the participants to introduce themselves. Ask each to stand, face the assemblage, give their name, organization and job title, and state how many months or years of experience they have in traffic operations. Invariably you will note a wide range of job titles and backgrounds. When they have finished, mention that you will try to pitch the level of the course appropriately for everyone, in the hope that each will get something out of it. Emphasize that it is clear that there are many individuals in the room with vast experience. Those participants can add a lot to the sessions if they can be induced to take part, with comments and questions. At this point you can encourage participation by offering to give away a toy car to anyone who asks a question or makes a comment. These cars can be purchased in "sheets" of 30 for about \$5 at Family Dollar stores, a chain with many outlets. The author takes no credit for discovering this little trick, but has found it very effective and well worth the personal outlay of about 15 cents per toy car.

The participants should be shown the Evaluation Form, which asks about sections of the course that might be expanded into follow-on courses of their own.

The PowerPoint presentation, Section 1, has an introductory slide that is not included in the Participant's Guide. It shows a failed pavement or large pothole in the Ansley Park area of Atlanta. The orange object on the pavement is the author's hat, shown to indicate the scale. You might state that the participants will have to find their own hardware store and pick out their own reflector, as work zones are beyond the scope of this one-day course!

SECTION 3 PAVEMENT MARKINGS

3.3 ATSSA VIDEO “RIGHT BEFORE YOUR EYES”

This is an entertaining, non-technical video for lay audiences. You may want to show just three or four minutes of it, so that the participants can decide whether it might be useful to show to community leaders, to help get their support for better marking.

3.6 RETROREFLECTIVE MARKINGS

The course materials include a length of white marking tape, so that participants can see the embedded glass beads.

3.9 ATSSA VIDEO: “PAVEMENT MARKING INSPECTION: TRAFFIC PAINT”

The course materials include an ATSSA video “Inspector’s Guide to Pavement Markings: Traffic Paint,” and another “Pavement Marking Inspection: Thermoplastic.” The former runs some 14 minutes and the latter is quite long at 21 minutes. You might ask the participants which one they would prefer to see. If they want the video on thermo, you will want to stop it when it gets to the review of the 10 steps.

SECTION 4 DELINEATORS

4.8 REFLECTORIZED FLEXIBLE POSTS

You may wish to attempt to start a discussion about the application of flexible posts. Some participants may call them a maintenance headache, always being knocked down. You might find that these individuals are using the posts to severely restrict motorists from doing something they very much want to do. For example, Gwinnett County attempts to use them as a median barrier, to prevent left turns into and out of driveways on busy arterials. When the posts are run down by “urban assault vehicles” (SUVs), Gwinnett concludes that these posts aren’t of much use.

You might ask the participants what they think of Figure 4.8.B. Rather than place the posts and block the accel-decel lane, do they think the agency should have required the apartment complex to move their sign back and lower their landscaping?

SECTION 5 SIGNALS

5.1 SAFE SIGNAL TIMING FOR PEDESTRIANS

It is well to take the time to be sure the participants understand the meaning of WALK and Flashing DONT WALK. Discuss walking speed, to see if the participants always use 4 feet per second, no matter what type of location. Do they know that the *Traffic Control Devices Handbook* recommends using only 3.5 near shopping centers, convalescent or rest homes, therapy centers, etc.? (See page 4-105). Shock your audience with the FHWA recommendation in the *Older Driver Design Handbook*, published 1998, page 14, that “To accommodate the shorter stride and slower gait of less capable (15th percentile) older pedestrians, and their exaggerated “start-up” time before leaving the curb, pedestrian control signal timing based on an assumed walking speed of 2.8 feet per sec is recommended.” Are “older pedestrians” found only at rest homes these days, or are they “everywhere”?

SECTION 9 IDENTIFYING LOCATIONS WITH IMPROVEMENT POTENTIAL

9.1 INSPECTIONS BY FIELD EMPLOYEES

Do the agencies represented in this course have any systems whereby employees have a duty to look for and report any road problems they see? Do the reports need to be in writing, or can they be radioed in? Do most of the employees participate? Is participation made a part of the employees' periodic evaluations?

9.5 TABLES OF EXPECTED VALUES

The course materials include tables for Gwinnett County (in metro Atlanta), Macon/Bibb County, and Savannah/Chatham County. The Participant's Guides should include an appendix with the set of tables for the urban area closest to the presentation site.

Improving Operational Safety on Local Roads and Streets

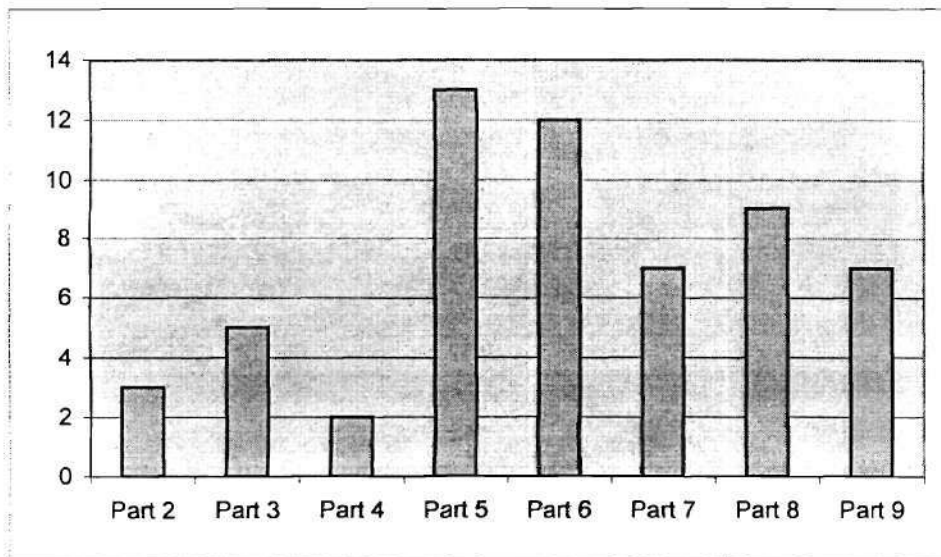
February 1, 2000 Alpharetta

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	14	16	1	0	31
2. The correlation between the course and the advertised objectives.	9	22	0	0	31
3. The instruction.	19	12	0	0	31
4. The services provided by the staff.	10	21	0	0	31
5. The clarity, completeness and promptness of receipt of program information.	15	15	1	0	31
6. The meeting facilities.	9	20	2	0	31
Totals:	76	106	4	0	186
Recommend this course to others.	YES 30	NO 1			

Parts of the course that participants would like to see expanded on:



Comments for the Alpharetta course:

Although course primarily designed for public works officials, it was informative and useful. Many of the same concerns are present in construction work zones.

May need to reduce the amount of pass-a-rounds and add copies of some of the articles for the students future use.

Wish we had more time.

The course provided a good synopsis on many subjects and brought up many topics that should be considered for future LTAP classes.

Very good course. Could be two days.

Course should be divided into 2 days. Too much material to cover in one day. More time on liability of not doing what you should be doing.

Very interesting presentation.

The course is too general.

Should be 1 day or 1-1/2 days with more detail.

An extremely effective program. Emphasize legal aspects.

The directions to the location of the class were very poor. If the directions are followed the building could not be found. These directions definitely need improvement.

Improving Operational Safety on Local Roads and Streets

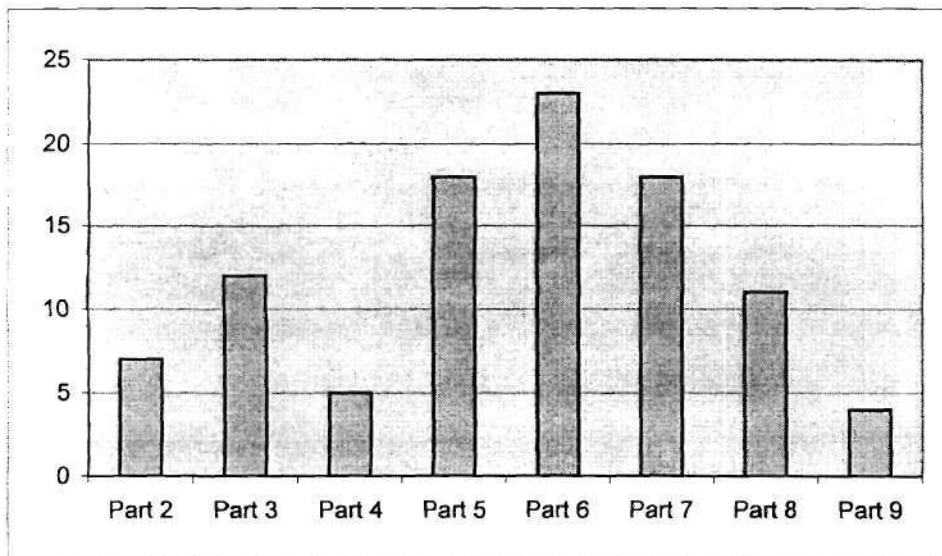
February 1, 2000 Macon

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	16	39	0	0	55
2. The correlation between the course and the advertised objectives.	10	44	1	0	55
3. The instruction.	32	23	0	0	55
4. The services provided by the staff.	18	36	1	0	55
5. The clarity, completeness and promptness of receipt of program information.	26	28	1	0	55
6. The meeting facilities.	24	30	1	0	55
Totals:	126	200	4	0	330
Recommend this course to others.	YES 51	NO 1			

Parts of the course that participants would like to see expanded on:



Comments for the Macon course:

Videos, more handouts.

Would like to see a course on street signs and marking only.

Dr. Parsonson is very knowledgeable on the subject. Keep the group involved. Good job.

Very knowledgeable and helpful.

Should be incorporated into Dr. Pete's five day course.

Good class.

This should be a 2 or 3 day class.

Should be at least a 3 day course. A lot of real good information for our field.

Very good overview course for all topics discussed.

Very interesting, did learn a lot. The course did helped me a lot.

Please have course dedicated more to maintenance and signage of old country roads.

It would be helpful to have information on how to obtain the various reference materials presented.

Personal experience of others and the instructor were very helpful.

Class was very informative.

County manager needs to be involved.

Maybe make this a 2 day course for some in-depth discussion.

Very interesting and enjoyable.

Signal warrants and justification could be addressed. New alternatives to traffic signals. This could be expanded to a 4 or 5 day course with further expansion of material.

Would like to hear more about safety enhancement.

Very good class and liked the instructor very much.

Make sure the coffee machine works.

The progression of the course did not follow schedule. The discussions were good in most cases. Some were led to far astray.

Dr. Parsonson is very knowledgeable. Enjoyed the workshop.

Improving Operational Safety on Local Roads and Streets

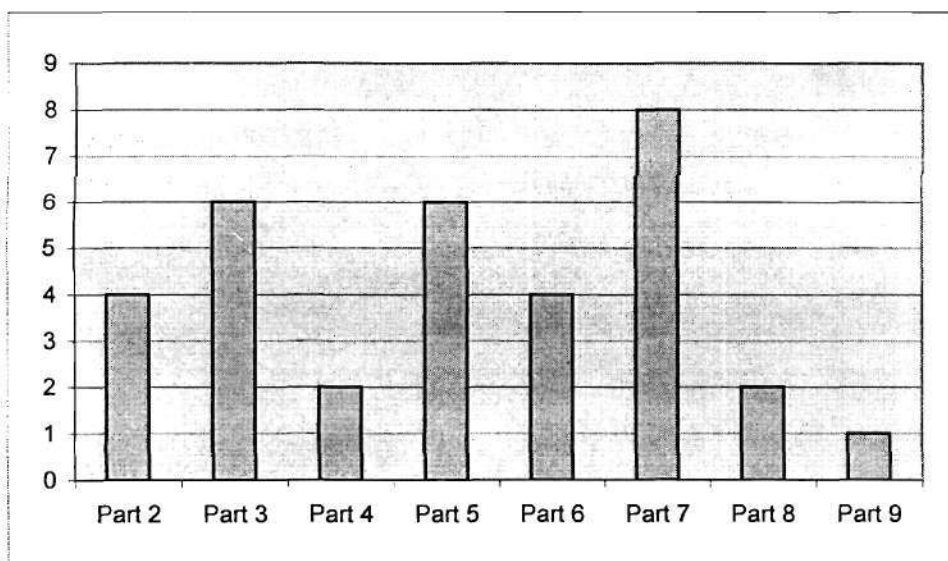
February 1, 2000 Savannah

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	1	16	0	0	17
2. The correlation between the course and the advertised objectives.	1	15	1	0	17
3. The instruction.	4	13	0	0	17
4. The services provided by the staff.	1	15	1	0	17
5. The clarity, completeness and promptness of receipt of program information.	2	15	0	0	17
6. The meeting facilities.	2	15	0	0	17
Totals:	11	89	2	0	102
Recommend this course to others.	YES 17	NO 0			

Parts of the course that participants would like to see expanded on:



Comments for the Savannah course:

Would have liked more in-depth info. Regarding thermoplastic paint. Enjoyed info about traffic calming. Everything is very relevant to transportation careers.

Allow more time to cover all material with discussion.

Thought it was a more useful class than some I have attended.

Enjoyed class, very informative.

Very well done - should be experienced by more significant personnel with cities, counties and DOT. A lot of good material.

Very informative.

The sections was covered very good. But I think the class needs to be a 2 day class.

Need more time to complete course.

Would like to have longer course on pedestrian and bicyclist safety. Areas where sidewalks and crosswalks are necessary and questions relating to proper installation, dimensions, locations, etc.

Improving Operational Safety on Local Roads and Streets

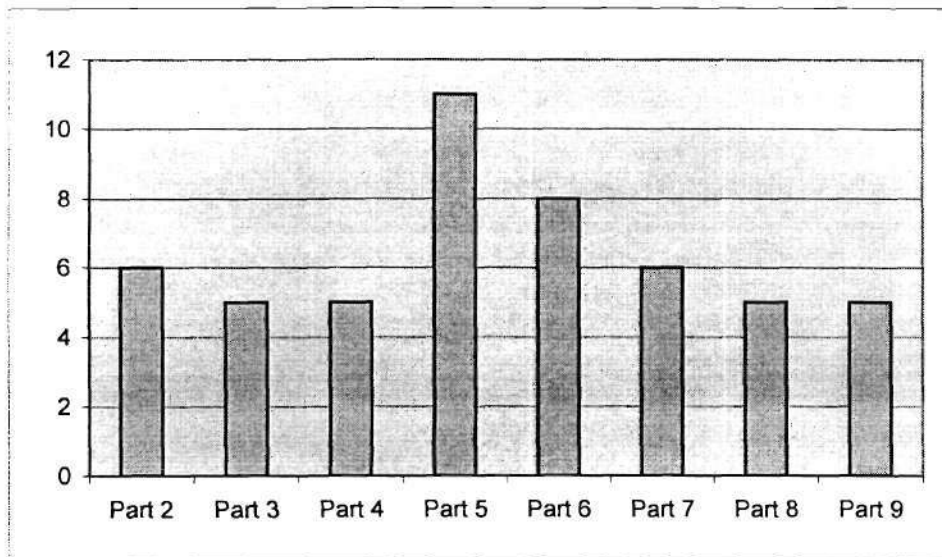
February 1, 2000 Valdosta

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	15	8	0	0	23
2. The correlation between the course and the advertised objectives.	6	17	0	0	23
3. The instruction.	11	12	0	0	23
4. The services provided by the staff.	9	14	0	0	23
5. The clarity, completeness and promptness of receipt of program information.	13	10	0	0	23
6. The meeting facilities.	12	11	0	0	23
Totals:	66	72	0	0	138
Recommend this course to others.	YES 21	NO 0			

Parts of the course that participants would like to see expanded on:



Comments for the Valdosta course:

Very good information on sign maintenance.

Thanks you for the car.

Should be a 2 day program or at least a day and a half.

Thank you.

Good presentation. Enjoyed program.

This course shed a light on a lot of material. The class should be at least 2 days.

This was a very interesting class, it refreshed a lot of things that I have studied in the past.

Case histories were as important as examples. Use more.

Rural counties participants probably need to hear less about signal lights and more about other subjects.

Very useful.

Good presentation.

This course should be given more time. 2 or 3 days. Cost is offset by information and knowledge gained.

The instructor, Dr. Parsonson, is very good and knowledgeable.

Breaks should be hourly to help keep students alert. Also time should be extended to 2 days. It shouldn't cram material.

Improving Operational Safety on Local Roads and Streets

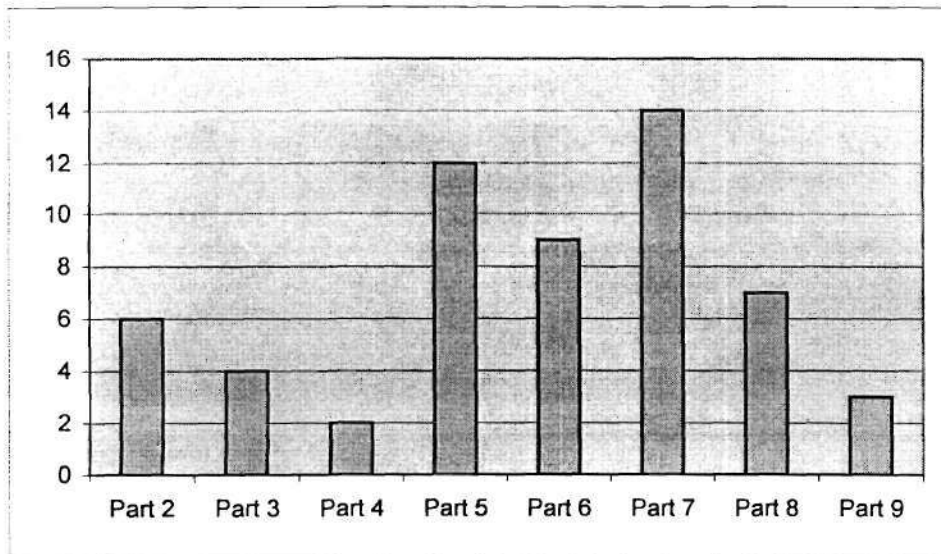
February 1, 2000 Athens

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	14	34	0	0	48
2. The correlation between the course and the advertised objectives.	10	38	0	0	48
3. The instruction.	29	19	0	0	48
4. The services provided by the staff.	8	34	3	3	48
5. The clarity, completeness and promptness of receipt of program information.	18	26	4	0	48
6. The meeting facilities.	15	32	1	0	48
Totals:	94	183	8	3	288
Recommend this course to others.	YES 46	NO 0			

Parts of the course that participants would like to see expanded on:



Comments for the Athens course:

Very well done. Thanks.

Covered information very well.

Very interesting. Thank you.

Was very interesting.

Schedule course to cover entire manual.

Too much time spent on sections 1-5. Sections 6-9 need more time. Sections 6-9 merit a complete course.

The subject that relates to me the most, we did not get to.

Wish we could have finished the entire course material.

Would like to see locations of restaurants for lunch. Offer more than one class in areas to give more opportunity and less driving time.

The instructor presented the material very well.

very informative.

Instructor was very good. Easy to comprehend.

Very good program and very timely.

Every phase of the course was great.

A lot of material packed into 1 day. Needs to be 2 days.

Need vendor for sandwiches at lunch time.

I think Ga. DOT should revise every city and county, that gets funds to have someone to attend this course. This would enable this knowledge to be spread to these areas that don't have a clue about signs or traffic engineering. This was a very informative course.

Excellent program, excellent length. Please offer it at least once a year.

Good instructor and course format.

The material is good.

Improving Operational Safety on Local Roads and Streets

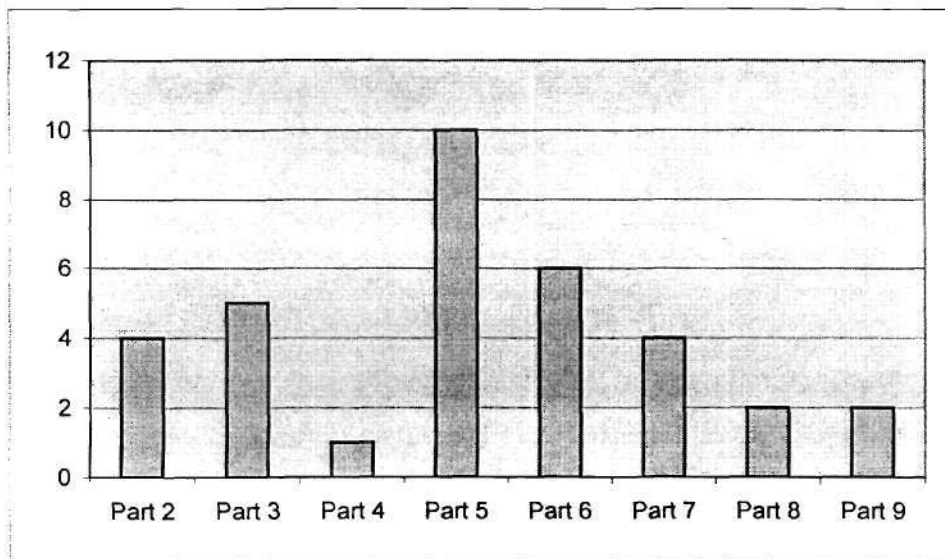
February 1,2000 Rome

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	14	15	0	0	29
2. The correlation between the course and the advertised objectives.	10	19	0	0	29
3. The instruction.	20	8	1	0	29
4. The services provided by the staff.	7	19	2	1	29
5. The clarity, completeness and promptness of receipt of program information.	14	15	0	0	29
6. The meeting facilities.	4	19	6	0	29
Totals:	69	95	9	1	174
Recommend this course to others.	YES 27	NO 0			

Parts of the course that participants would like to see expanded on:



Comments for the Rome course:

Great job!

Room was cold and breakroom was too far away.

Enjoyed.

Instructor was excellent. Thoroughly knowledgeable about all areas of the program.

Informative and useful current data.

I would love for Dr. Pete to teach a G-DOT sponsored course on traffic signalization.

Good course, lots of information.

Great course.

Improving Operational Safety on Local Roads and Streets

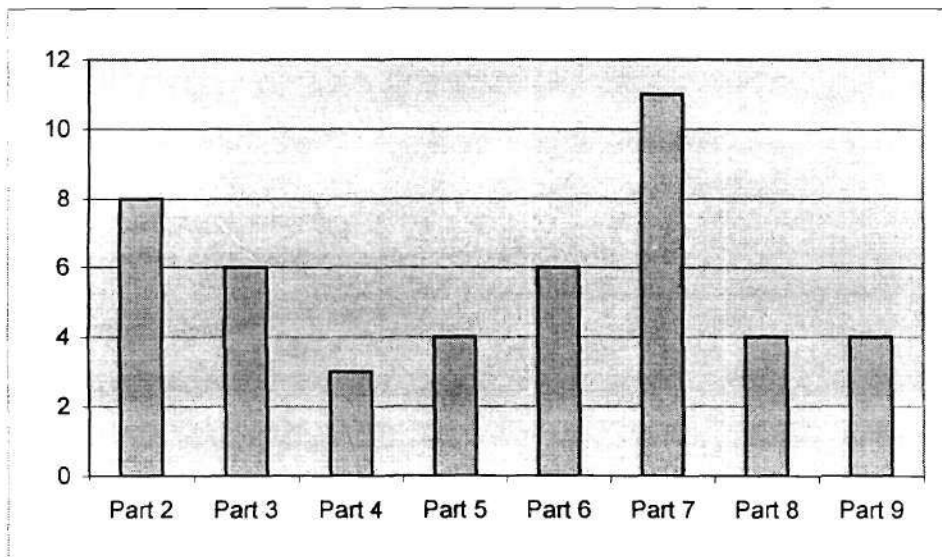
February 1, 2000 Sandersville

Academic Administrator: Peter Parsonson

General Evaluation of the Course:

	<u>Exceeded</u> <u>Expectations</u>	<u>Met</u> <u>Expectations</u>	<u>Needs</u> <u>Improvement</u>	<u>Not</u> <u>Applicable</u>	<u>Total</u> <u>Responses</u>
1. The Program	12	20	0	0	32
2. The correlation between the course and the advertised objectives.	7	21	3	1	32
3. The instruction.	21	8	3	0	32
4. The services provided by the staff.	13	16	2	1	32
5. The clarity, completeness and promptness of receipt of program information.	16	14	1	1	32
6. The meeting facilities.	22	8	2	0	32
Totals:	91	87	11	3	192
Recommend this course to others.	YES 30	NO 0			

Parts of the course that participants would like to see expanded on:



Comments for the Sandersville course:

Very good course.

We need to somehow get more public works/roads people involved.

Split the topics into 2 LTAP sessions. There is more than adequate material.

Proceeded at nice speed. Excellent prop material. May be worth mentioning that many of the references passed are available on the web.

This course is a must for anyone dealing directly or indirectly with the traveling public. It would improve the safety of the motorists by following these procedures.

Very good.

Enjoyed the class, made some good points.

Needs to have microphone available - hard to hear.

Needs to stay on time and finish book. Too many passed around handouts for the way we were set-up.

Created greater awareness and very much appreciated.

Good information - needed by Co. public works personnel. Good to hear Dr. Pete again.